FINAL REPORT

Innovative GIS and Information Technologies Supporting Wide Area Assessment of UXO Sites

ESTCP Project MM-0537

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Acronyms

ASP	Active Server Pages
ASR	Archive Search Report
COTS	commercial-off-the-shelf
CSDGM	Content Standard for Digital Geospatial Metadata
CSM	Conceptual Site Model
DEM	Digital Elevation Model
DERP	Defense Environmental Restoration Program
DoD	Department of Defense
DSB	Defense Science Board
ESTCP	Environmental Security Technology Certification Program
FGDC	Federal Geographic Data Committee
FLBGR	Former Lowry Bombing and Gunnery Range
FUDS	Formerly Used Defense Sites
GDC	Geophysical Data Center
GIS	Geographic Information Systems
HE	high explosives
HeliMag	Helicopter MTADS Magnetometry (see MTADS)
HSI	Hyperspectral Imaging
IT	Information Technology
LAN	Local Area Network
LiDAR	Light Detection and Ranging
MEC	Munitions and Explosives of Concern
MRA	Munitions Response Area
MRF	Munitions Related Feature
MRS	Munitions Response Site
MTADS	Multi-Sensor Towed Array Detection System
QA	Quality Assessment
QC	Quality Control
RDBMS	Relational Database Management System
SAR	Synthetic Aperture Radar

SDE	Spatial Database Engine
SDSFIE	Spatial Data Standards for Facilities, Infrastructure & Environment
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
UXO	Unexploded Ordnance
VLSO	Very Large Scale Orthophotography
VLS	Very Large Scale
WAA	Wide Area Assessment

Acknowledgments

Demonstration of Innovative GIS and Information Technologies for Wide Area Assessment of UXO Sites documents the development and use of Geographic Information Systems and Information Technologies for the management, analysis and communication of data for Wide Area Assessment surveys. The work was performed by Sky Research, Inc. of Oregon, with Dr. John Foley serving as Principal Investigator.

Funding for this project was provided by the Environmental Security Technology Certification Program Office. This project offered the opportunity to develop and standardize procedures to manage, manipulate, process and visualize the large WAA datasets generated by the pilot program. The overall program was performed to support of the Department of Defense's efforts to evaluate wide area assessment technologies for efficient the characterization and investigation of large Department of Defense sites.

We wish to express our sincere appreciation to Dr. Jeffrey Marqusee, Dr. Anne Andrews, and Ms. Katherine Kaye of the ESTCP Program Office for providing support and funding for this project.

Executive Summary

Geographic Information Systems (GIS) and Information Technologies (IT) were demonstrated concurrently with the wide area assessment (WAA) technology demonstrations conducted for the ESTCP WAA Pilot Program at five demonstration sites: Pueblo Precision Bombing Range #2, Colorado; Kirtland Precision Bombing Ranges, New Mexico; Victorville Precision Bombing Ranges, California; Borrego Maneuver Area, California; and Former Camp Beale, California.

The complex geospatial technology infrastructure demonstrated for this project was required to manage, manipulate, process and visualize the large WAA datasets generated by the pilot program. GIS and IT technologies were used to integrate these datasets, including primary-processed datasets, such as basic georeferenced imagery and sensor data points, and a wide range of derivative datasets, such as geophysical anomaly pick points, target and range feature detections and density models, from each demonstration into one internet-accessible Enterprise GIS designed for application inter-operability and internet connectivity. Centralized data storage and management were provided by Sky Research IT infrastructure and were scaled to accommodate the requirements of the program. The geodatabase technology included the ESRI ArcSDE® geodatabase server running on the Oracle 10g relational database management system. Database schema development utilized ESRI ArcGIS® software and MS Visio®.

The results demonstrated the value of GIS and geospatial technologies to integrate multiple-sensor/multiple-scale WAA datasets. These results include the following:

- demonstration of enterprise-class GIS capabilities in a collaborative on-line environment and facilitation of intra-project spatial data communications and analyses;
- establishment of a rigorous geospatial environment for storing ground truth and fiducial datasets;
- development of a geospatial modeling framework for combining individual sensor survey and analysis results into a comprehensive, multiple-input assessment of munitions contamination characteristics and distribution across each demonstration site; and
- development of a geodatabase schema to implement the Conceptual Site Models for each site.

These technologies also successfully supported the general goals of the pilot program of establishing technically achievable and regulator-acceptable processes for characterizing large munitions response areas (MRA), delineation of associated munitions response site (MRS) boundaries, and provision of reliable data that could be used to support regulatory disposition of non-MRS portions of MRAs.

1 Introduction

1.1 Background

Munitions and explosives of concern (MEC) contamination is a high priority problem for the Department of Defense (DoD). Recent DoD estimates of MEC contamination across approximately 1,400 DoD sites indicate that 10 million acres are suspected of containing MEC. Because many sites are large in size (greater than 10,000 acres), the investigation and remediation of these sites could cost billions of dollars. However, on many of these sites only a small percentage of the site may in fact contain MEC contamination. Therefore, determining applicable technologies to define the contaminated areas requiring further investigation and munitions response actions could provide significant cost savings. Therefore, the Defense Science Board (DSB) has recommended further investigation and use of Wide Area Assessment (WAA) technologies to address the potential these technologies offer in terms of determining the actual extent of MEC contamination on DoD sites (DSB, 2003).

In response to the DSB Task Force report and recent Congressional interest, the Environmental Security Technology Certification Program (ESTCP) designed a Wide Area Assessment pilot program that consists of demonstrations at multiple sites to validate the application of a number of recently developed and validated technologies as a comprehensive approach to WAA. These demonstrations of WAA technologies include deployment of high airborne sensors, helicopter-borne magnetometry arrays and ground surveys.

This report documents the Geographic Information Systems (GIS) and Information Technology (IT) technologies used to integrate datasets from each demonstration into one internet-accessible Enterprise GIS. The Enterprise GIS was comprised of GIS and IT tools designed for application inter-operability and internet connectivity. The datasets incorporated into the GIS included both primary-processed datasets, such as basic georeferenced imagery and sensor data points, and a wide range of derivative datasets, such as geophysical anomaly pick points, target and range feature detections and density models. The GIS provides tools to assist with validation of these inputs and provides systematic methods to analyze, summarize and communicate the data content to accomplish the goals and objectives of the demonstration.

The following WAA demonstration sites were included in this GIS demonstration:

- Pueblo Precision Bombing Range #2 in Otero County, Colorado
- Borrego Maneuver Area in northeastern San Diego County, California
- Kirtland Precision Bombing Ranges in Bernalillo County, New Mexico
- Victorville Precision Bombing Ranges in San Bernardino County, California
- Former Camp Beale in Yuba and Nevada Counties, California

1.2 Objectives of the Demonstration

The general goal of the pilot program was defined as the establishment of technically achievable and regulator-acceptable processes for characterizing large munitions response areas (MRAs). The Enterprise GIS deployed for the pilot program supported these goals by providing the technology to support site characterization, including the delineation of associated munitions response sites (MRSs), and by providing reliable data that could be used to support regulatory disposition of non-MRS portions of the MRA. Last, the technologies demonstrated could be used for future risk analysis and cost estimation by site remediators.

The specific goals of this demonstration were to evaluate and demonstrate the value of GIS and geospatial technologies to integrate multiple-sensor/multiple-scale WAA datasets. To achieve this goal, the following objectives were formulated for this project:

- provide enterprise-class GIS capabilities in a collaborative on-line information portal environment for the pilot program to facilitate intra-project spatial data communications and analyses;
- provide a rigorous geospatial environment for storing ground truth and fiducial datasets, and to make concise geostatistical assessments of data validation criteria at the demonstration sites;
- provide a geospatial modeling framework for combining individual sensor survey and analysis results into a comprehensive, multiple-input assessment of munitions contamination characteristics and distribution across each demonstration site; and
- develop and populate a geodatabase schema that implements the Conceptual Site Model (CSM) for each site.

The demonstrated technologies are all components of the complex geospatial technology infrastructure required to manage large WAA data structures. To provide focus to the GIS demonstration and related performance metrics, this infrastructure was generalized into four technology classes that correspond to the main objectives of the demonstration: WAA dataset management; geodatabase implementation of the CSM; creation of an enterprise GIS; and framework modeling and analysis.

A determination of success for this demonstration was based on the successful:

(i.) Development of the Enterprise GIS system that provided access to all members of the WAA project team to the datasets collected for the pilot program;

(ii.) Management of these datasets; and

(iii.) Development of the capabilities to query the system and perform interactive modeling to allow users to actively combine and visualize multiple sensor datasets to derive MRS boundary delineations and MEC contamination distributions, and compare results with ground verification results.

1.3 Regulatory Drivers

The demonstration sites were all classified by the United States Government as a Formerly Used Defense Site (FUDS) under the Defense Environmental Restoration Program (DERP). The use of GIS and IT technologies were not required by DERP.

1.4 Stakeholder Issues

ESTCP managed the stakeholder issues as part of the WAA-PP. ESTCP used a process that ensured that the information generated by the WAA surveys at each demonstration site was useful to a broad stakeholder community (e.g., technical project managers and Federal, State, and local governments, as well as other stakeholders). Furthermore, the internet-accessible survey information was made available to the WAA Advisory Group members throughout the duration of the pilot program.

2. Technology Description

2.1 Technology Development and Application

Powerful, commercial-off-the-shelf (COTS) GIS technology has existed for some time and is used within the U.S. geospatial data infrastructure at all levels of government. GIS technology allows integration of a number of datasets and provides a platform to store, analyze, integrate, model, visualize, and document very large volumes of data. Enterprise database technology is used to store and index large, multi-user datasets while GIS software tools provide the critical organizing links between the raw sensor datasets, analytical and interpretive results, and program management tasks.

Sky Research developed a fully functional enterprise GIS infrastructure to support two large-scale WAA projects: one at the Former Lowry Bombing and Gunnery Range (FLBGR), Colorado, and the other at Former Camp Hale, Colorado. This infrastructure included the servers, software, high-speed Internet access, and IT staff needed to support multi-sensor datasets covering large sites. The Sky Research GIS was built using ESRI ArcGIS® technology including ArcInfo 9.x with Spatial Analyst, 3D Analyst, and Feature Analyst; ArcSDE running on Oracle 10g; ArcIMS Internet map services; ENVI hyperspectral image analysis, and a number of custom applications. Hardware and operating systems were largely based on Intel-class processors running Red Hat Linux and Windows, and were managed for security, availability, and application responsiveness.

2.2 Technology Components

Centralized data storage and management were provided by Sky Research IT infrastructure and were scaled to accommodate the requirements of the program. The geodatabase technology included the ESRI ArcSDE® geodatabase server running on the Oracle 10g relational database management system (RDBMS). Database schema development utilized ESRI ArcGIS® software and MS Visio®. Data generated and integrated within the geodatabase included high airborne datasets (Light Detection and Ranging [LiDAR] terrain data; very large scale orthophotography [VLSO]; hyperspectral imaging [HSI] derivative imagery; and synthetic aperture radar [SAR] derivative imagery); Helicopter Multi-Sensor Towed Array Detection System (MTADS) Magnetometry (HeliMag) derived data; and the results of ground-based digital geophysical mapping sensor surveys. The HeliMag datasets were managed in the Sky Research Geophysical Data Center (GDC). The GDC is a custom geophysical database application, running concurrently with ArcSDE on the Oracle RDBMS, and is designed to manage geophysical datasets from a variety of sensor configurations. Figure 1 is a generalized schematic for the WAA process that shows how the sensor systems, processing steps and data flows, and CSM-based schema development were managed within the geodatabase.

Metadata for all spatial datasets was developed and stored in the geodatabase using ArcCatalog, in compliance with the Federal Geographic Data Committee (FGDC) Content Standard for Digital Geospatial Metadata (CSDGM). Metadata is documentation for a digital geospatial

dataset. It is a text document that provides a who, what, when, where, why and how description about the data. Examples of metadata include but are not limited to:

- **Sensor imagery datasets**: timeframe for data collection, collection parameters, processing methods used to create the imagery, and who created the metadata (this data was provided for Ortho, LiDAR, and Helimag data)
- **Analysis datasets:** source data collection (imagery), analyst that created the dataset, processing methods, time of analysis, summary of the purpose of the dataset. This includes derivative geophysical and high airborne datasets, and data synthesis datasets.

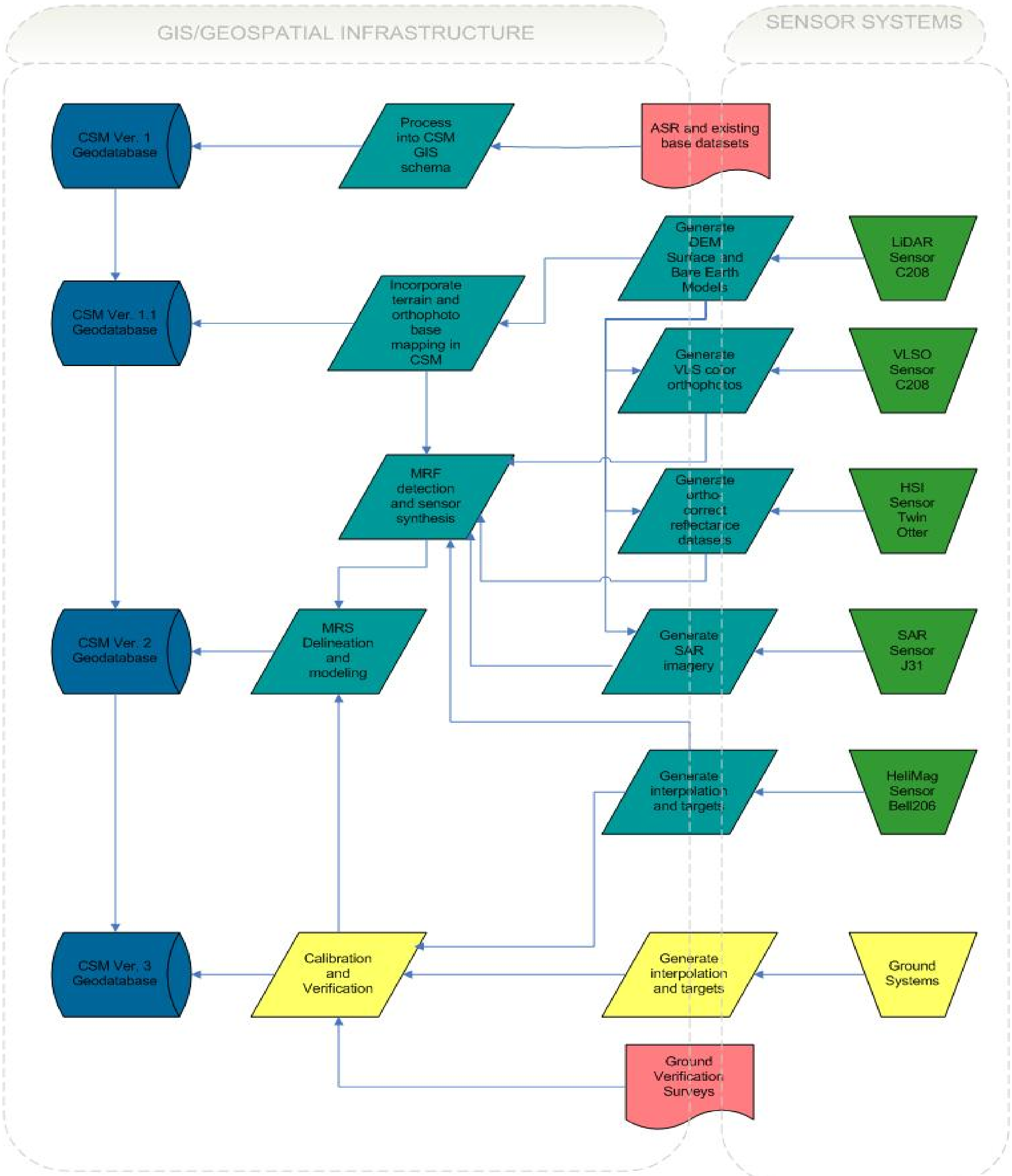

Figure 1. WAA geodatabase schematic.

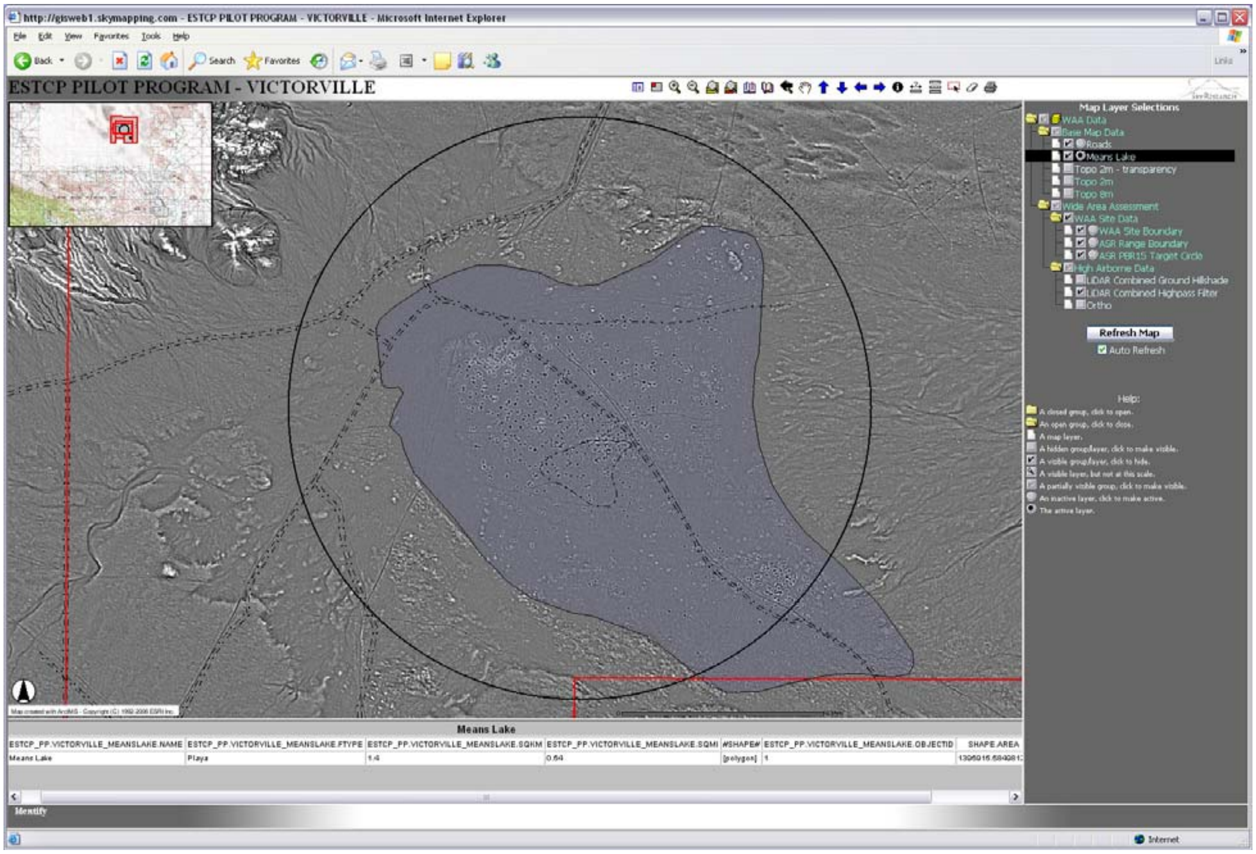

Figure 2. ArcIMS data viewer for WAA demonstration project.

Geodatabase viewers and distributed database access were implemented using both direct GIS client software connection to the geodatabase and web-based viewers accessing the database via web services established using the ESRI ArcIMS® internet mapping services software (Figure 2). Geodatabase connections and map services were embedded in a custom ASP.NET Information Portal environment that provided access to spatial data viewers, in addition to the project documentation, project status information and contacts. Access to the ESRI ArcGIS® client software and licenses through the Citrix MetaFrame® Presentation Server web-interface provided remote users with full GIS data viewing and analysis functionality on their desktop, through a standard web browser using a secure log-in.

The modeling environment was based on the ArcGIS geoprocessor and the models were developed as geoprocessing tools in the ArcGIS environment. They were available using the ArcMap desktop client either locally or remotely by using the Citrix ArcGIS Desktop Server. Saved and named output from the models could be immediately loaded into existing ArcIMS data viewers. Because the models were implemented as ArcGIS geoprocessing tools, they were available on any ArcMap client machine with appropriate licensing and access to the input datasets, simply by loading a toolbox file onto the machine. The models were also made

available via Citrix Presentation Server, which provided users access to fully-functional remote sessions of the ESRI ArcGIS desktop software (ArcView license level) and retrieved data stored on the remote computer network.

A detailed guidance document was developed as part of this project to document the use of the data viewers and models (Sky Research, 2007). This guidance document was provided to the United States Army Corps of Engineers for incorporation into the data library. Other pre-established IT tools that comprised the Sky Research Enterprise GIS infrastructure include multi-terabyte network attached storage for high-performance server storage, extensive middle storage tiers for on-line archives and workspace, and high-performance file, database, middleware and web servers running Windows® and Linux® operating systems. Networking was based on a gigabit/100mb Local Area Network (LAN) with fiber-optic Internet connectivity via the Ashland Fiber Network. Attached workstations were high-performance multi-processor 2+GHz systems running ArcGIS®, ENVI®, Microstation® and an extensive suite of other geospatial and image processing software packages.

2.3 Previous Testing of the Technology

Many of the GIS component technologies were first applied at the FLBGR for the integration and management of SAR, HSI, LiDAR and large-scale digital orthophotography WAA datasets and results (Foley, 2004; Sky Research, 2005; Hodgson, 2004). At FLBGR, the site GIS was adapted and extended for a GIS-based data management and decision support system for the overall project (Hodgson, 2004). At the Camp Hale munitions contamination site in the high Rocky Mountains west of Denver, Sky Research managed a site GIS for a large-scale, long-term munitions remediation and risk-reduction program involving WAA, ground-based surveys, Area of Concern analysis, and focused munitions recovery and disposal operations (Hodgson, 2003).

2.4 Factors Affecting Cost and Performance

The most important factor affecting cost and performance of GIS technologies in support of WAA data collection and analysis activities is that of scale. While some factors, such as disk storage requirement costs, scale proportionately with the acreage and number of active WAA GIS projects, the baseline infrastructure cost requirements of software licensing, staff training and development, systems configuration and design, and facilities development generally improve in cost efficiency as project data volumes increase.

Organizing WAA data using GIS is the most practicable, cost effective means of managing and integrating data from a multiple-sensor WAA demonstration project. For future, production-level WAA on active military munitions remediation sites, the integration of WAA results with base-mapping and archival information represents a major cost benefit to the overall remediation project. These benefits carry beyond the site remediation process to future uses of the site, both through the establishment of baseline aerial photo and detailed engineering-quality terrain data, and the delineation of munitions-related site constraints and future development requirements in a standardized, multiple-use, consolidated data entity.

2.5 Advantages and Limitations of the Technology

Geospatial and GIS technologies are considered to be enabling technologies for multiple-sensor WAA of MRAs. Without the geospatial data integration and spatial modeling capabilities afforded by these technologies, together with a very high level of integration with the mainstream IT infrastructure of governments and businesses, the efficient analysis and use of WAA sensor data would not be possible. Currently, the most significant limitations of the technologies for this purpose include: 1) an insufficiency of well-developed multiple-sensor fusion algorithms and processing strategies; 2) limitations imposed by sensor technologies and associated data processing, geo-positioning, and imaging techniques; and 3) immature geospatial data models to manage, share, and utilize WAA results.

3. Demonstration Design

3.1 Performance Objectives

Performance objectives provide the basis for evaluating the performance of the technology. Table 1 lists the performance objectives for the GIS demonstration, along with criteria and metrics for evaluation.

Table 1. Performance Objectives

Objective Type	Primary Performance Objective	Expected Performance Metric
Qualitative	Comprehensive metadata repository	Metadata available for each dataset
	Efficient access to large raster and vector datasets	Multi-user ArcIMS access to raster and vector datasets
	Multiple-user access	Access to Web-based data viewers and project information portals to all members of WAA Advisory Group
	RDBMS integration and compatibility	Databases integrated and compatible
	FGDC Metadata and SDSFIE compliance	FGDC and SDSFIE compliance
	Integrated Quality Assessment (QA) and Quality Control (QC) functionality	Tools available for QA and QC
Quantitative	Secure repository large enough to store WAA data	Server storage meets or exceeds WAA storage needs
	Geodatabase populated with available data layers	Data layers integrated in geodatabase
	Co-registration accuracies of sensor datasets	Meets or exceeds target accuracies for each sensor
	Timely incorporation of WAA data and analysis results	On portal within 2 days of data receipt or analysis completion
	Timely execution of GIS analyses	Completion of tasks within scheduled timeframe

3.2 Selecting Test Sites

The selection of the WAA demonstration sites for the WAA pilot program was based on criteria selected by the ESTCP Program Office in coordination with the WAA Advisory Group of state and federal regulators.

3.3 Test Site History/Characteristics

The demonstration sites selected for the WAA pilot program covered under this GIS demonstration were as follows:

- Pueblo Precision Bombing Range, Colorado
- Borrego Maneuver Area, California
- Kirtland Precision Bombing Range, New Mexico
- Victorville Precision Bombing Range, California
- Former Camp Beale, California

For each demonstration site, a spatial data viewer was developed to allow all stakeholders access to an integrated data environment for multi-sensor viewing and assessment. The data viewer for each demonstration site included base map data and the primary and derivative datasets for each WAA sensor used on the demonstration site. Interactive mapping tools allowed the user to create custom views and combinations of the data to support an assessment.

3.4 Pre-Demonstration Testing and Analysis

The GIS infrastructure required to support the WAA pilot program was evaluated and prepared for the WAA demonstrations. This included all hardware and software, such as client/server configurations, storage devices, database management tools, and ESRI software applications. All of these infrastructure components were tested on similar WAA sites prior to the start of the GIS demonstration for the WAA demonstration sites.

3.5 Testing and Evaluation Plan

3.5.1 Demonstration Set-Up and Start-Up

Sky Research coordinated with the ESTCP program coordination consultant, Versar, Inc., to establish an initial CSM-based version of the WAA data model for the demonstration sites. For each demonstration site, a geospatial database schema was developed in accordance with the CSM and in compliance with the Spatial Data Standards for Facilities, Infrastructure & Environment (SDSFIE). The database schemas were subsequently populated as the sensor data from the demonstration sites were collected. An existing web-based ESTCP Project Information Portal for the Pueblo demonstration site was updated to incorporate the spatial data viewer and expanded to incorporate equivalent Project Information Portals for all of the demonstration sites.

3.5.2 Period of Operation

The GIS demonstration ran concurrently with the WAA pilot program. Initial spatial data viewers were created for the Pueblo, Kirtland and Borrego demonstrations. As demonstration sites were added to the Program, additional spatial data viewers were created (i.e., for Victorville Precision Bombing Range and Former Camp Beale).

As sensor datasets were received throughout the course of each demonstration, they were made available for interactive visualization and inspection on the Project Information Portals. The

derivative datasets resulting from spatial modeling were uploaded as soon as analysis was completed. The interactive capabilities of the spatial data viewers and remote ArcGIS modeling access allowed users to actively combine and visualize multiple sensor datasets to derive MRS boundary delineations and MEC contamination distributions as they became available.

3.5.3 Operating Parameters for the Technology

Two distinct options were developed to make the WAA pilot program datasets accessible to all program members: 1) the spatial data viewers were incorporated into the Project Information Portals and 2) remote access was provided to the GIS desktop applications and modeling tools. The spatial data viewers provided quick, generalized functionality for use on a daily basis and the remote modeling environment provided higher-level functionality for specialized analysis needs.

The spatial data viewers provided secure on-line access to interactive mapping sites for each demonstration site. The data viewers provided user-friendly tools for data review, analysis, and assessment specific to each demonstration site. The interactive nature of the data viewers allowed users to overlay and compare data layers at any desired scale. Each data viewer was customized to incorporate the data layers and mapping tools appropriate to the individual site, while maintaining visual and functional consistency among all of the data viewers. The data viewers were designed to be accessed using an Internet Explorer browser window and required a valid username and password to access the sites. All members of the WAA Advisory Group were provided access to the sites.

The modeling component of the Enterprise GIS system, hosted on the Sky Research network, was accessible by logging in to a secure web site from any desktop computer with Microsoft Internet Explorer. A Citrix plug-in was installed the first time the site was accessed. Remote sessions of the GIS desktop applications appeared and functioned just as they would if the software was installed on the local machine, except that data was retrieved and stored on the remote network. Benefits of the modeling environment included: 1) secure, direct access to all project geodatabase and file datasets; 2) access to advanced GIS tools & model parameters; 3) established, repeatable modeling workflows; and 4) the ability to create and save custom maps and model output and software configuration settings.

The modeling tools provided the functionality required for sensor evaluation, multiple-input data fusion, and site contamination summarization. Although default modeling parameters were incorporated into the models, the user must have knowledge of data fusion and statistical analysis to produce meaningful results. When used by a knowledgeable analyst, the modeling environment can provide powerful tools for multi-sensor data synthesis to improve WAA munitions contamination assessment capabilities and evaluate the sensitivity of the variables in the modeling.

3.5.4 Technical Approach

A series of tasks were identified for this demonstration, corresponding with each of the four main IT/GIS program components. These components are listed in this section, and the actual implementation is described in detail in the Performance Assessment section that follows:

Establish the GIS framework for the project. This effort implemented the geodatabase and Information Portal infrastructure for the demonstration, and established the geodatabase storage schema for each WAA site. This included the following:

- Establishment of the project geodatabase and implementation in Oracle SDE
- Establishment of the GDC support for HeliMag and ground-based geophysical sensors
- Development of the geodatabase schema to support the CSM
- Establishment of the site Information Portal

Populate the GIS with data. Existing available information was loaded into the geodatabase and Information Portal. Existing information about the physiography and past use of the site was the starting point for the WAA process, used to plan the UXO modeling framework and sensor data acquisition strategies.

Develop WAA data visualization and modeling tools. For each site data visualization and modeling tools were implemented to provide a framework for understanding the spatial distribution of munitions contamination indicators on each.

Centralized data management. As sensor datasets were acquired and primary processing was completed, raw data were archived and processed sensor data were loaded into the geodatabase for distribution, visualization, and analysis. The process was fully documented with metadata and processing summary reports published on the project Information Portal. This stage was critical to the WAA process by providing a data verification environment, a final synthesis of the WAA modeling results, and a distribution, review and publication medium for the assessment.

3.5.5 Demobilization

No demobilization was required for this demonstration. GIS schemas and datasets were provided to the ESTCP Program Office. The data were also archived by Sky Research.

4. Performance Assessment

Performance assessment for the GIS and IT part of the WAA demonstration discussed below is based on a description of how the four components of the GIS/IT demonstration were actually implemented:

- The GIS framework for the project including storage, databases and other system resources was successfully established and functioned as expected.
- Existing spatial datasets were loaded into the WAA GIS to support data acquisition planning and other mapping requirements, and WAA datasets were loaded and analyzed
- Data visualization and modeling tools were developed to integrate the various results of the WAA into summary components of the Conceptual Site Model.
- Centralized data management coordination and access for multiple projects and contractors, and final data products distribution were all implemented according to plan.

4.1 Establish the GIS Framework

The GIS infrastructure successfully established for the WAA pilot program demonstrations included solutions for centralized data storage, versioning, multiple user access and viewing, QC, modeling and analysis, and data export/transfer.

A geodatabase schema for the WAA data model (Figure 3) and SDSFIE was implemented in the Oracle-SDE geodatabase to support the loading and management of all spatial datasets (e.g., sensor, analysis, modeling and verification datasets). The Sky Research GDC, housed on the same Oracle database server as the geodatabase, was prepared to store the primary geophysical datasets for the project. The GDC was integrated with the geodatabase to allow for the storage, management, display and analysis of derivative geophysical datasets (e.g., anomaly locations and attributes, interpolated data surfaces, and point density surfaces). As the demonstrations progressed, the individual project schemas continued to mature.

The existing web-based ESTCP Project Information Portal for the Pueblo demonstration site was updated to incorporate the spatial data viewer and expanded to incorporate equivalent Project Information Portals for all of the additional demonstration sites. The spatial data viewers were designed to provide an efficient, customizable means for publishing spatial datasets and results for display, QC and analysis to suit project needs. Secure access for all program members was established through individual log-in credentials.

Data processing and analysis models were developed using ArcGIS tools to support the establishment of efficient, repeatable workflows for the Sky Research analysts. A Citrix-based remote access portal was implemented to allow program members access to the desktop GIS environment, for advanced data analysis capabilities and use of the custom WAA-PP project models. Secure access was established through individual log-in credentials.

4.2 Loading Data into the GIS

Initially, existing data including site boundaries, base mapping, general orthophotography, DEMs, USGS topographic sheets and historical training area boundaries were loaded into the GIS to provide a foundation for planning and managing the WAA data acquisitions. These datasets were used by all WAA project participants to plan and spatially coordinate multiple survey and data acquisition projects and included all the information necessary to document the site profiles described in the Conceptual Site Model (CSM) narratives.

Project geodatabases were organized according to the initial CSM version for each demonstration site. Iterative versions of the CSMs were developed as the geodatabases were populated with WAA data as the demonstrations progressed. The categories and datasets outlined below define the general structure of these CSM versions. The database schemas varied slightly by demonstration site depending on available historical data, site characteristics, and WAA technologies used. A more complete description of the CSM versions and associated schemas for each demonstration site is included in Appendix A.

1) CSM Version 0: Available and historic datasets were used to create base map data and target boundaries inherited from investigations occurring prior to the start of the project.

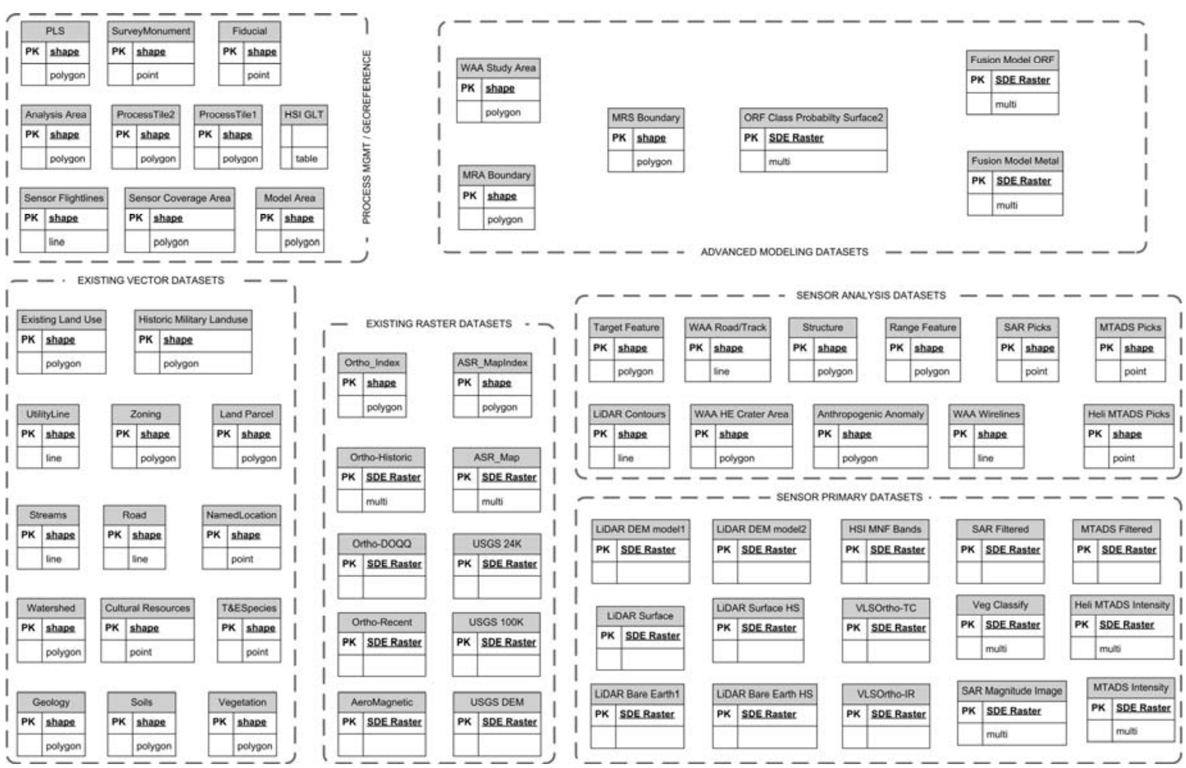

Figure 3. WAA geospatial data model.

2) CSM Version 1. High airborne derivative datasets were incorporated into the CSM and included datasets of extracted features, such as craters, features of interest, and infrastructure features.
3) CSM Version 2. Low airborne and ground survey derivative datasets were incorporated into the CSM and included datasets such as the HeliMag target density analysis and selected anomalies.
4) CSM Version 3. The validation datasets were incorporated into the CSM and included the visual field reconnaissance locations and information and the intrusive investigation locations and results.

Metadata for all spatial datasets were developed and stored in the geodatabase, in compliance with the Federal Geographic Data Committee (FGDC) Content Standard for Digital Geospatial Metadata (CSDGM).

4.3 WAA Data Visualization and Modeling Tools

For each site, geospatial data loading, analysis, and modeling tools were used to: (i) assure proper coordination of mapping datums and projections; (ii) integrate datasets from disparate sources into a cohesive data structure; (iii) prepare derivative datasets (e.g. hillshade visualizations of DEMs, or density distributions of geophysical anomalies); (iv) perform feature extractions from multiple datasets; and (v) model the spatial distribution of MRFs in support of CSM profile modeling.

At the project outset, map production tools were used to support field crews in the planning and documentation of data acquisition, for ground target placement, and for site access and verification strategies. As the demonstrations progressed, basic analytical tools were made available via the data viewers, allowing the user to overlay various combinations of map layers. Basic analytical techniques included spatial overlays of both raster (i.e. imagery) and vector (e.g., point, line or polygon) data layers and map queries for viewing the tabular information associated with a data feature. In addition, measuring tools and coordinate tools were made available for retrieving spatial information.

One of the key ideas behind Conceptual Site Models is the notion that the CSM is a continually refined model based upon ongoing site investigations (USACE 2003). The CSM uses a series of abstract models, or “Profiles” to describe the overall distribution of UXO potential, physical and environmental parameters, and potentially affected receptors across a site. The iterative development of a CSM starts with the accumulation of historical and background data, and continues to increase in detail and resolution as investigation and remediation activities on the site progress.

The principal functions of the CSM geodatabase are to aggregate this increasing detail into a comprehensive database that can be maintained with ongoing activities at each site, and to provide efficient access and visualization of the data to support the profiles described in the

narrative CSM. To support the CSM updates that incorporate WAA datasets, a modeling framework was established that demonstrates how simple non-parametric spatial analysis methods such as buffering, spatial overlays and occurrence density modeling can be used to aggregate multiple disparate datasets into generalized views of munitions contamination potential in support of the CSM Facility Profile. These tools can be used in conjunction with Physical Profile updates represented by the LiDAR and orthophoto WAA data to update the CSM Pathway Analysis that relates receptor and source at each site.

The modeling framework implemented a progressive abstraction of information from primary sensor information, to class models that summarize the distribution of ordnance activity areas according to type (target area, firing point maneuver area, etc.), to general summaries of OE potential across the site based on all indicators. Figure 4 shows the hierarchy of the models that were used to abstract sensor data into class models that characterize the distribution of CSM Facility Profile ordnance activity area features by type, and the general models that summarize the extent of potentially contaminated lands and areas with no known indicators other than inclusion in the overall site boundary.

These models are all simple spatial models that combine location information about OE indicators, assign areas of influence for those features by spatial buffering and spatial density assessment, and perform weighted spatial overlays to assess the combined influence of multiple factors on each location across the site. Such models are useful to summarize the regions of a site most likely to be contaminated, and how they relate to exposure factors such as land use, zoning and transportation routes.

Feature classes (such as craters, target aiming features, selected HeliMag anomalies, etc.) were used as input for models that generated datasets characterizing specific site attributes. Models could be run multiple times with varied user input parameters to characterize the effect of different sensors, different levels of generality, and different sensitivity thresholds.

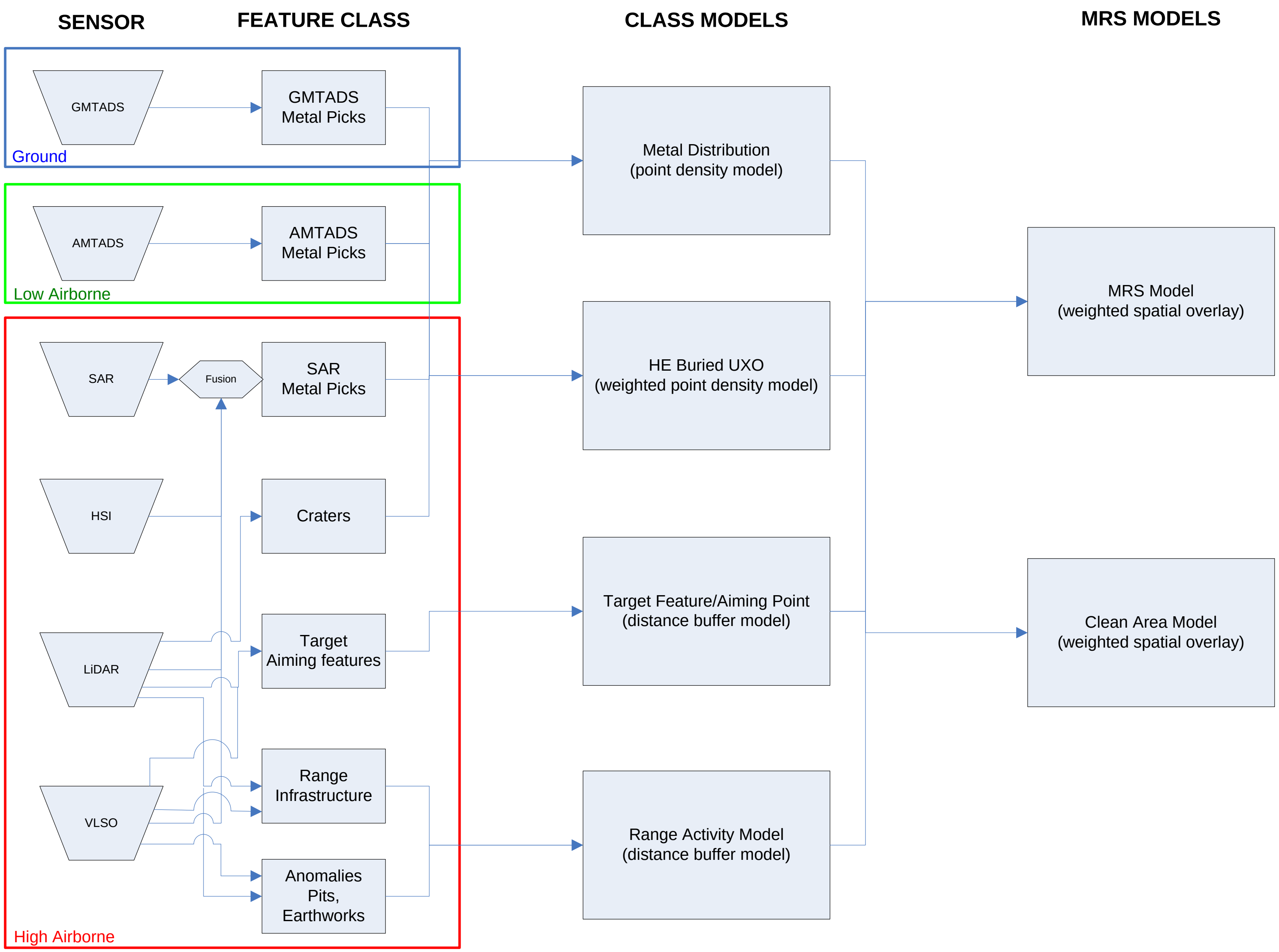

Figure 4. Multi-sensor modeling framework for WAA.

Models were developed to derive abstract representations of four different munitions contamination site characteristics.

- *METAL DISTRIBUTION* – This model describes the distribution of metal objects across the site. It is a weighted density model computed as a magnitude surface of points per unit area.
- *HE BURIED UXO* – This model describes the assumed distribution of dud high explosive (HE) munitions based on the distribution of HE craters across the site. This is a weighted density model computed as a magnitude surface of points per unit area.
- *TARGET FEATURES / AIMING POINTS* – This model describes the regions of the site that are proximate to bombing or artillery target aiming point locations. It is a spatial buffer model that delineates all areas within a specified distance of a target feature.
- *RANGE ACTIVITY* – This model describes the regions of the site associated with areas used for transport, access, or other activities on the range. It is a spatial buffer model that delineates all areas within a specified distance of a road, structure, or other evidence of human activity.

Class model parameters for each class model type are provided in Table 2 below.

Table 2. Class Model Parameters

Model	Parameter	Description
Metal Distribution	Feature Class Weight	Includes, weights, or excludes the three potential sources of metal features (SAR, ground data, helicopter survey data)
	Kernel Size	Generalize or provide fine detail in the density map
	Output Products	Define model output products including a density surface output raster, a thresholded boundary polygon feature class, a contour feature class, and spatial statistics in tabular format
HE Buried UXO	Input Feature Class List	Specify input feature classes (craters, HeliMag picks and/or ground survey picks)
	Feature Class Weight	Weight crater detections by size or other attribute
	Kernel Size	Generalize or provide fine detail in the output density map
	Output Products	Define model output products including a density surface output raster, a thresholded boundary polygon feature class, a contour feature class, and spatial statistics in tabular format
Target Feature / Aiming Point	Feature Class Weight	Weight target feature detections by sensor, size, type, detection confidence or other attribute of the feature class
	Buffer Distance, Range or Attribute Field	Delineate the area of influence around the feature (can be general for the model or set to a field in the attribute table so that different features are buffered at different distances)

Model	Parameter	Description
	Output Products	Define the model output products including a boundary polygon feature class, a contour feature class of variable buffer ranges, a raster representation of buffer ranges for input to the MRS models, and spatial statistics in tabular format
Range Activity	Feature Class Weight	Weight feature detections by sensor, size, type, detection confidence or other attribute of the feature class
	Buffer Distance, Range or Attribute Field	Delineate the area of influence around the feature (can be general for the model or set to a field in the attribute table so that different features are buffered at different distances)
	Output Products	Define model output products including a boundary polygon feature class, a contour feature class of variable buffer ranges, a raster representation of buffer ranges for input to the MRS models, and spatial statistics in tabular format

Figures 5 through 9 shows examples how class models can be derived from the feature classes.

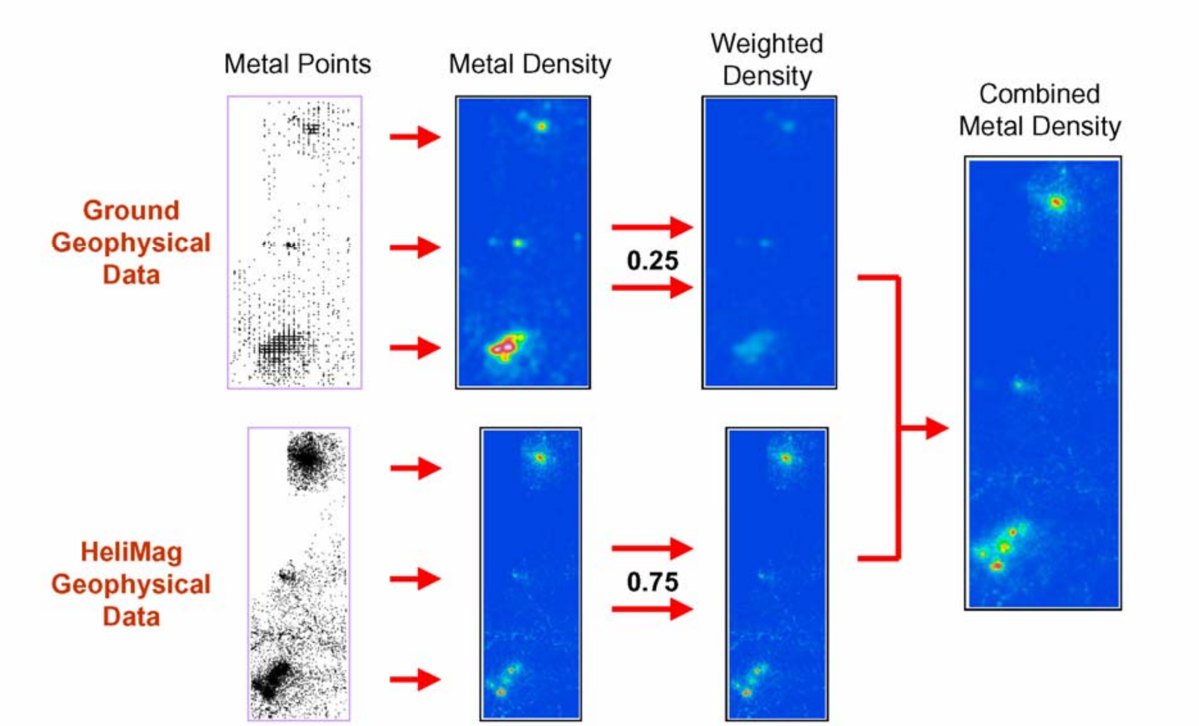

Figure 5. Metal distribution model example using a varied weighting of ground geophysical data and HeliMag geophysical data.

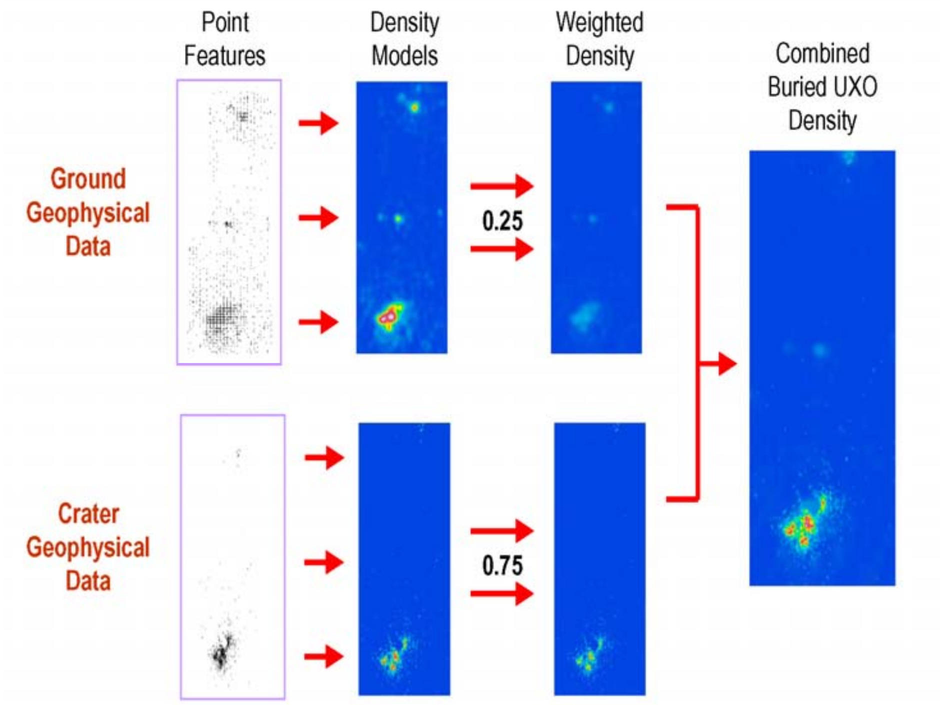

Figure 6. Buried UXO model example using a varied weighting of ground geophysical data and LiDAR-derived crater data.

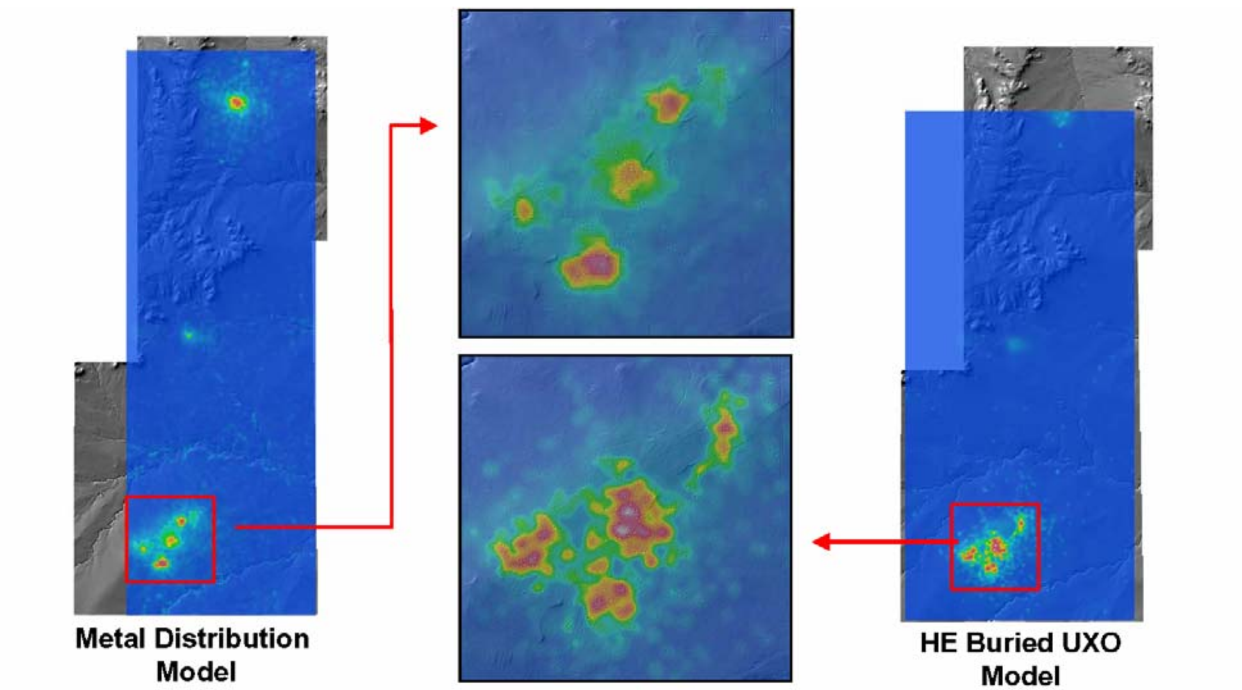

Figure 7. Comparison of the modeling results of the metal distribution model and the buried UXO model.

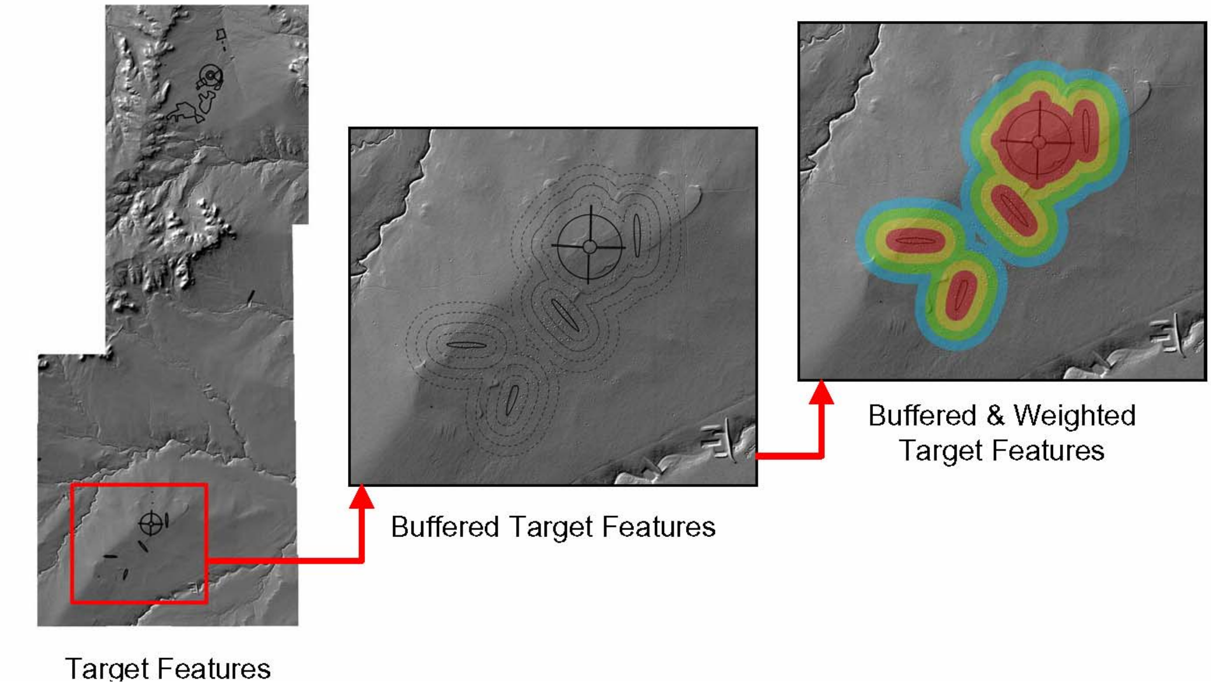

Figure 8. Target feature model developed using target features extracted from LiDAR and orthophotography sensor data.

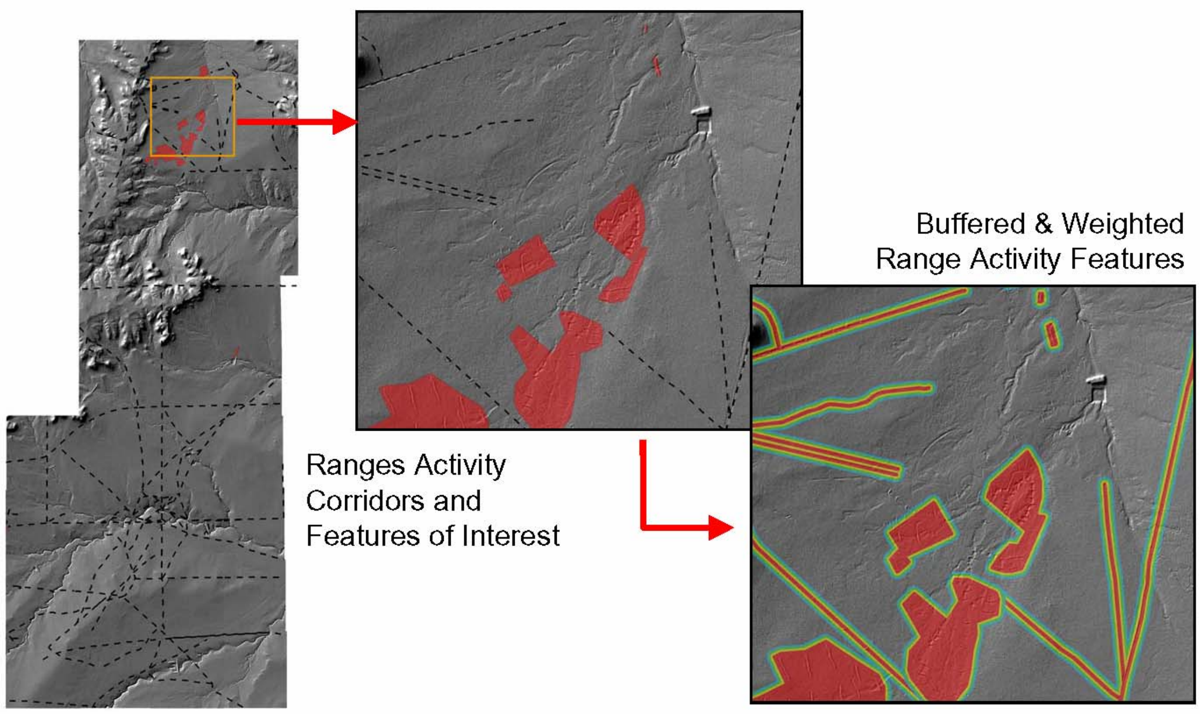

Figure 9. Range activity model developed using infrastructure features extracted from LiDAR and orthophotography sensor data.

Class models can be combined and weighted to create MRS models delineating MRS boundaries. There are two basic MRS models that can be run and output multiple times with varied parameters to evaluate and substantiate results.

- *MRS MODEL* – Delineates areas of probable munitions contamination.
- *CLEAR AREA MODEL* – Delineates areas with no evidence of contamination.

These models can be run using a variety of inputs and weight from the class models. An example result is provided in Figure 10.

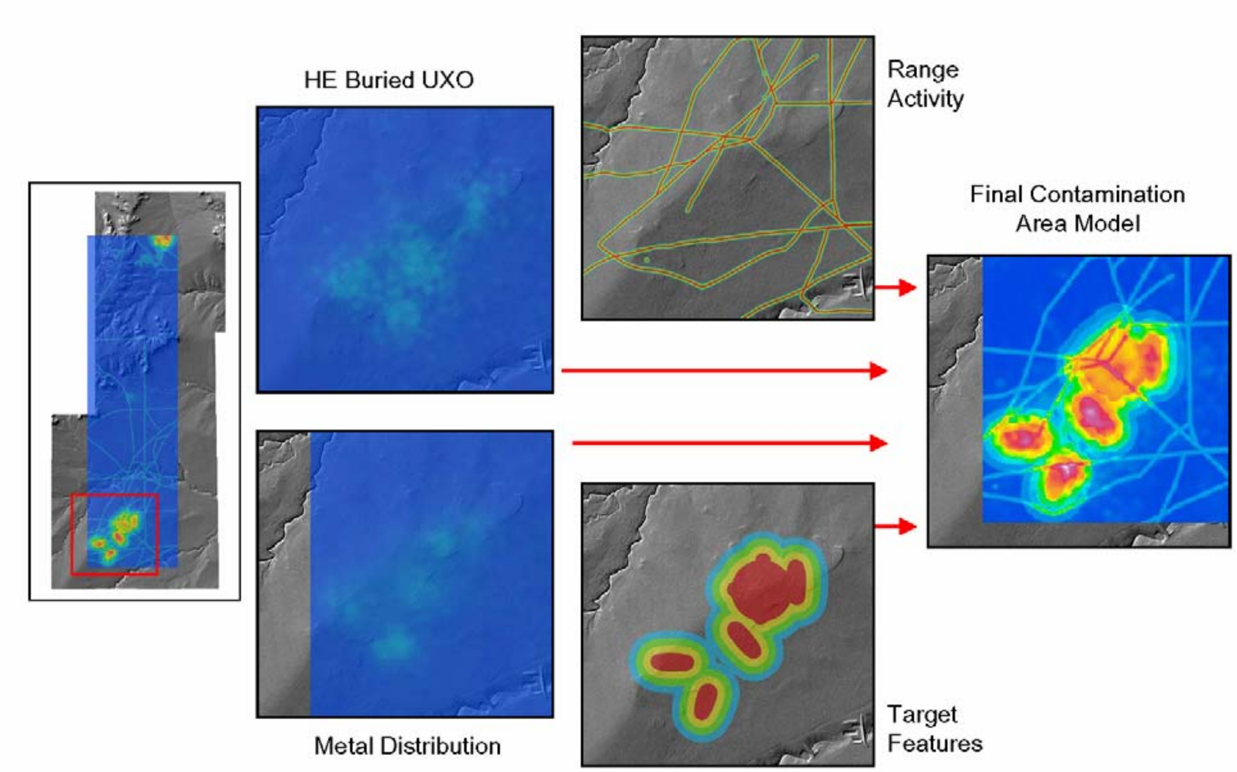

Figure 10. Contamination area model example using HE Buried UXO, Metal Distribution, Range Activity and Target Features class model inputs.

4.4 Management of WAA Data

As sensor datasets were acquired and primary processing was completed, raw data were archived and processed sensor data were loaded into the geodatabase for distribution, visualization, and analysis. The site characterization process was documented through the metadata maintained in the geodatabase and data uploaded to the Project Information Portal.

Data management for each demonstration site included the following steps, as appropriate:

- LiDAR – Loaded DEM to geodatabase, computed hillshaded imagery, input feature detection results and exported DEM for Ortho/LiDAR/SAR/HIS geocorrection processing.
- Orthophotography – Loaded imagery to geodatabase and input feature detection results.
- Hyperspectral Imaging (HSI) – Loaded processed imagery to geodatabase and input detection results (Pueblo only).
- Synthetic Aperture Radar (SAR) – Loaded processed imagery to geodatabase and input detection results (Pueblo only).
- HeliMag – Loaded data points, anomaly picks, and supporting data to the GDC and update the geodatabase with detections, attributes and interpolated data surface rasters.
- Ground Surveys – Loaded data points, anomaly picks and supporting data to the GDC and updated the geodatabase with detections, attributes and interpolated data surface rasters.
- Metadata – Prepared FGDC-compliant metadata for each dataset, including concise descriptions of the dataset generation process, accuracy metrics and data attributes.
- Data Transformation – Transformed sensor datasets (e.g., datum, projection, units, raster-vector conversion and georeferencing) for GIS integration, as necessary.
- Data Modeling – Developed and maintained data modeling tools and input derivative datasets from modeling and analysis.
- Data Distribution – Provided centralized data storage, access and distribution for the project team.
- Web Maintenance – Performed ongoing maintenance of Project Information Portals, including updates of the spatial data viewers and inter-project documentation.
- Archiving – Performed on-going flat file and database archiving.

Table 3 provides a summary of the volume of WAA pilot program data managed for each demonstration site.

Table 3. Data Management Statistics

Demonstration Site	Database Storage	Flat-File Storage
Pueblo Precision Bombing Range #2	21 GB	198 GB
Borrego Maneuver Area	16 GB	35 GB
Kirtland Precision Bombing Ranges	22 GB	26 GB
Victorville Precision Bombing Range	12.5 GB	27 GB
Former Camp Beale	109 GB	84 GB

4.5 Performance Criteria

The performance of the GIS and IT supporting technologies was measured against the performance criteria as described in Table 4.

Table 4. Performance Criteria for WAA GIS

Type of Performance Objective	Performance Criteria	Description
Qualitative	Comprehensive metadata repository	Metadata availability
	Efficient access to large raster and vector datasets	Availability of datasets on ArcIMS viewer
	Multiple-user access	Access to Web-based data viewers for all members of WAA Advisory Group
	RDBMS integration and compatibility	RDBMS integrated and compatible
	FGDC Metadata and SDSFIE compliance	FGDC and SDSFIE compliance
	Integrated QA and Quality Control QC functionality	Tools available for QA and QC on the ArcIMS viewer
Quantitative	Secure repository large enough to store WAA data	Server storage meets or exceeds WAA storage needs
	Geodatabase populated with available data layers	Available data layers integrated in geodatabase
	Co-registration accuracies of sensor datasets	Meets or exceeds target accuracies for each sensor
	Timely incorporation of WAA data and analysis results	On portal within 2 days of data receipt or analysis completion
	Timely execution of GIS analyses	Completion of tasks within scheduled timeframe

4.6 Performance Confirmation Methods

Demonstration performance is evaluated according to the objectives and criteria cited in Sections 3.1 and 4.5.

Table 5. Performance Metrics Confirmation Methods and Results

Performance Metric	Confirmation Method	Expected Performance	Performance Achieved
Metadata Availability	Metadata available on the ArcIMS site	Metadata available	Pass
Access to raster and vector datasets	Efficient access to large raster and vector datasets via ArcIMS	Access available to users with log-in	Pass
Multiple-user access	Access to Web-based data viewers for all members of WAA Advisory Group	Access available to any number of users in different organizations and agencies	Pass
RDBMS integration and compatibility	RDBMS integrated and compatible, with all information accessible via ArcIMS through spatial overlays	Information integrated and compatible	Pass
FGDC Metadata and SDSFIE compliance	Compliance with standard	Metadata compliant	Pass (all metadata created using ArcCatalog FGDC metadata editor)
QA/QC functionality	Integrated QA and QC functionality via analytical tools available on ArcIMS viewers	Analytical tools available	Tools developed and available
Data server storage	Server stores all WAA sensor and derived data.	Server storage meets or exceeds WAA storage needs.	Server stored all data
Data layer integration into geodatabase	Geodatabase populated with available data layers	Geodatabase populated	All data layers incorporated

Performance Metric	Confirmation Method	Expected Performance	Performance Achieved
Co-registration accuracies of sensor datasets	All sensor datasets were co-registered in the GIS using common datums and coordinate systems	Co-registration expected to meet or exceed the best accuracy of each sensor system	LiDAR, Orthophotography, SAR and ground data co-registered at sub-meter accuracies. HSI was co-registered for SAR target discrimination, but was not needed for large feature detection.
Timely incorporation of WAA data and analysis results	Timing of portal upload of completed GIS analyses	On portal within 2 days of data receipt or analysis completion	WAA data and analysis results uploaded on time
Timely execution of GIS analyses	Timing of portal upload of completed GIS analyses	Completion of tasks within scheduled timeframe	GIS analyses completed on time

5. Cost Assessment

5.1 Cost Reporting

Cost information associated with the demonstration of all GIS/IT technologies, as well as associated activities, were tracked and documented before, during, and after the demonstration to provide a basis for determination of the operational costs associated with this technology. For this demonstration, Table 6 contains the cost elements that were tracked and documented for this demonstration. These costs include operational costs associated with database design and implementation; salary and travel costs for GIS and management staff; costs associated with the processing, analysis, comparison, and modeling of datasets generated by this demonstration.

Table 6. Cost Tracking

Cost Category	Details	Costs ($)
Establish GIS	Develop geodatabase, information portal, create ArcIMS sites for each demonstration site	$29,279
Populate GIS	Upload data for each demonstration site	$40,068
Establish WAA Strategy	Develop visualization and analytical tools and schemas for demonstration site data	$36,900
Manage WAA Data	Data Management: geospatial data loading and analysis	$45,335
	Modeling: develop modeling methodology and tools	$25,103
Management & Reporting	Labor: management, contracting and reporting	$78,985
	Travel	$11,790
	Materials/Postage (e.g. disk drives , shipping costs)	$1,570
	Total Technology Cost	**$269,030.00**
	Demonstration Sites	**5**
	Unit Cost	**$53,806/site**

5.2 Cost Analysis

The major cost driver for GIS and IT support for WAA projects is the staff time to implement, manage and document the WAA datasets. However, as data management and analysis methods

for WAA projects are streamlined, the amount of labor required to implement and manage new WAA projects will decline.

Project management and reporting were also a significant cost for this demonstration, as the project was conducted under the WAA pilot program and therefore required more meetings, travel and reporting than would generally be expected for a production level survey.

6. Implementation Issues

6.1 Regulatory and End-User Issues

The ESTCP Program Office established an Advisory Group to facilitate interactions with the regulatory community and potential end-users of this technology. Members of the Advisory Group included representatives of the USEPA, State regulators, USACE officials, and representatives from the services. ESTCP staff worked with the Advisory Group to define goals for the WAA pilot program and develop Project Quality Objectives.

There will be a number of issues to be overcome to allow widespread implementation of WAA beyond the pilot program. Most central is the change in mindset that will be required if the goals of WAA extend from delineating target areas to collecting data that are useful in making decisions about areas where there is not indication of munitions use. Therefore, the challenge for adoption of a WAA approach with respect to regulatory acceptance may be the collection of sufficient data and evaluation that the applicability of these technologies to uncontaminated land and understanding of the results. Similarly, demonstrating that WAA data can be used to provide information on target areas regarding boundaries, density and types of munitions to be used for prioritization, cost estimation and planning will require that the error and uncertainties in these parameters are well understood.

7. References

US Army Corps of Engineers, "Conceptual Site Models For Ordnance and Explosives (OE) and Hazardous, Toxic, and Radioactive Waste (HTRW) Projects" Manual No. 1110-1-1200 3 February 2003

Foley, J., "UXO Wide Area Assessment at the Former Lowry Bombing and Gunnery Range": 2004 Partners in Environmental Technology Technical Symposium & Workshop, Washington D.C.; December 2004.

Hodgson, J., "A New Paradigm for UXO Information Management Using Enterprise Geographic Information Systems": UXO Forum, St. Louis, MO; March 2004.

Hodgson, J., "The Geophysical Data Center: Turning the UXO Information Glut into a Project Asset": UXO Forum, St. Louis, MO; March 2004.

Hodgson, J., "Development of a Comprehensive Geographic Information System": Sustainable Range Management Conference, Charlotte, NC; March 26, 2003.

Sky Research, Inc.; GIS System Guidance Document; ESTCP Project 200537: Innovative GIS and Information Technologies for Wide Area Assessment of UXO Sites; October 2007.

Sky Research, Inc.; WAA Modeling for Munitions Characterization White Paper; ESTCP Project 200537: Innovative GIS and Information Technologies for Wide Area Assessment of UXO Sites; March 2006.

Sky Research, Inc.; Demonstration Plan; ESTCP Project 200537: Innovative GIS and Information Technologies for Wide Area Assessment of UXO Sites; August 2005.

Sky Research, Inc.; Final Wide Area Assessment Report, Former Lowry Bombing and Gunnery Range, Arapahoe County, Colorado; Submitted to Jerry Hodgson, USACE – Omaha; February, 2005.

8. Points of Contact

Table 7. Points of Contact

Point of Contact	Organization	Phone/Fax/email	Role in Project
Dr. John Foley	Sky Research, Inc. 445 Dead Indian Road Ashland, OR 97520	(Tel) 541.552.5141 (Fax) 720.293.9666	Principal Investigator
Ms. Terri Ayers	Sky Research, Inc. 445 Dead Indian Road Ashland, OR 97520	(Tel) 541.552.5113 (Fax) 541.488.4606	Project Manager
Mr. Jerry Hodgson	USACE Omaha District 215 N. 17th Street Omaha, NE 68102-4978	(Tel) 402.221.7709 (Fax) 402.221.7838	Federal Advocate
Mr. Scott Millhouse	USACE, Huntsville Center	(Tel) 256.895.1607	COR Engineering Support

Project Lead Signature:

John E. Foley

Appendix A

WAA-PP Geodatabase Schemas

Pueblo WAA Geodatabase Schema

XML schema file: WAA_Schema_Pueblo.xml

Feature Classes

Simple feature class
CSM0_SITE_BOUNDARY

Geometry *Polygon*
Contains M values *No*
Contains Z values *No*

Field name	Data type	Allow nulls	Default value	Domain	Prec-ision	Scale	Length
OBJECTID	Object ID						
SITE_NAME	String	Yes					50
AREA_HA	Double	Yes			0	0	
AREA_ACRES	Double	Yes			0	0	
COMMENT_	String	Yes					50
AREA	Double	Yes			0	0	
LEN	Double	Yes			0	0	
SHAPE	Geometry	Yes					
SHAPE_Length	Double	Yes			0	0	
SHAPE_Area	Double	Yes			0	0	

Simple feature class
CSM0_TARGET_AREA

Geometry *Polygon*
Contains M values *No*
Contains Z values *No*

Field name	Data type	Allow nulls	Default value	Domain	Prec-ision	Scale	Length
OBJECTID	Object ID						
TARGET_NAME	String	Yes					50
AREA_ACRES	Double	Yes			0	0	
AREA_HA	Double	Yes			0	0	
COMMENT_	String	Yes					50
SOURCE	String	Yes					50
AREA	Double	Yes			0	0	
LEN	Double	Yes			0	0	
SHAPE	Geometry	Yes					
SHAPE_Length	Double	Yes			0	0	
SHAPE_Area	Double	Yes			0	0	

Simple feature class
CSM1_1KM_TILES

Geometry *Polygon*
Contains M values *No*
Contains Z values *No*

Field name	Data type	Allow nulls	Default value	Domain	Prec-ision	Scale	Length
OBJECTID	Object ID						
COL_ID	String	Yes					50
ROW_ID	Short integer	Yes			0		
ANALYST	Short integer	Yes		WAA_ANALYST	0		
ANALYSIS_START_TIME	Date	Yes			0	0	8
ANALYSIS_END_TIME	Date	Yes			0	0	8
QC_ANALYST	Short integer	Yes		WAA_ANALYST	0		
ANALYSIS_QC_START_TIME	Date	Yes			0	0	8
ANALYSIS_QC_END_TIME	Date	Yes			0	0	8
TILE_ID	String	Yes					10
ANALYST_COMMENT	String	Yes					50
QC_COMMENT	String	Yes					50
CRATER_CNT	Short integer	Yes			0		
AREA	Double	Yes			0	0	
LEN	Double	Yes			0	0	
SHAPE	Geometry	Yes					
SHAPE_Length	Double	Yes			0	0	
SHAPE_Area	Double	Yes			0	0	

Simple feature class
CSM1_AREA_OF_INTEREST

Geometry *Polygon*
Contains M values *No*
Contains Z values *No*

Field name	Data type	Allow nulls	Default value	Domain	Prec-ision	Scale	Length
OBJECTID	Object ID						
AOI_TYPE	Short integer	Yes		WAA_AOI_TYPE	0		
AREA_HA	Double	Yes			0	0	
AREA_ACRES	Double	Yes			0	0	
CENTROID_X	Double	Yes			0	0	
CENTROID_Y	Double	Yes			0	0	
COMMENT_	String	Yes					50
AREA	Double	Yes			0	0	
LEN	Double	Yes			0	0	
SHAPE	Geometry	Yes					
SHAPE_Length	Double	Yes			0	0	
SHAPE_Area	Double	Yes			0	0	

Simple feature class
CSM1_CRATERING_FEATURE

Geometry *Polygon*
Contains M values *No*
Contains Z values *No*

Field name	Data type	Allow nulls	Default value	Domain	Prec-ision	Scale	Length
OBJECTID	Object ID						
CRATER_TYPE	Short integer	Yes	0	WAA_CRATER_TYPE	0		
MIN_Z	Double	Yes			0	0	
MAX_Z	Double	Yes			0	0	
COMMENT_	String	Yes					50
CENTROID_Y	Double	Yes			0	0	
CENTROID_X	Double	Yes			0	0	
CRATER_DEPTH_M	Double	Yes			0	0	
AREA	Double	Yes			0	0	
LEN	Double	Yes			0	0	
SHAPE	Geometry	Yes					
SHAPE_Length	Double	Yes			0	0	
SHAPE_Area	Double	Yes			0	0	

Simple feature class
CSM1_FEATURE_OF_INTEREST

Geometry *Polygon*
Contains M values *No*
Contains Z values *No*

Field name	Data type	Allow nulls	Default value	Domain	Prec-ision	Scale	Length
OBJECTID	Object ID						
FEATURE_TYPE	Short integer	Yes		WAA_FEATURE_TYPE	0		
VALIDATION	Short integer	Yes	0	BooleanSymbolValue	0		
CENTROID_X	Double	Yes			0	0	
CENTROID_Y	Double	Yes			0	0	
AREA_HA	Double	Yes			0	0	
AREA_ACRES	Double	Yes			0	0	
COMMENT_	String	Yes					50
PRIMARY_SENSOR	Short integer	Yes		WAA_SENSOR_TYPE	0		
SECONDARY_SENSOR	Short integer	Yes		WAA_SENSOR_TYPE	0		
AREA	Double	Yes			0	0	
LEN	Double	Yes			0	0	
SHAPE	Geometry	Yes					
SHAPE_Length	Double	Yes			0	0	
SHAPE_Area	Double	Yes			0	0	

Simple feature class
CSM1_INFRASTRUCTURE_CORRIDOR

Geometry *Polyline*
Contains M values *No*
Contains Z values *No*

Field name	Data type	Allow nulls	Default value	Domain	Prec-ision	Scale	Length
OBJECTID	Object ID						
CORRIDOR_TYPE	Short integer	Yes	0	WAA_CORRIDOR_TYPE	0		
LENGTH_M	Double	Yes			0	0	
MIN_X	Double	Yes			0	0	
MIN_Y	Double	Yes			0	0	
MAX_X	Double	Yes			0	0	
MAX_Y	Double	Yes			0	0	
PRIMARY_SENSOR	Short integer	Yes		WAA_SENSOR_TYPE	0		
COMMENT_	String	Yes					50
LEN	Double	Yes			0	0	
SHAPE	Geometry	Yes					
SHAPE_Length	Double	Yes			0	0	

Simple feature class
CSM1_MASK_AREA

Geometry *Polygon*
Contains M values *No*
Contains Z values *No*

Field name	Data type	Allow nulls	Default value	Domain	Prec-ision	Scale	Length
OBJECTID	Object ID						
MASK_TYPE	Short integer	Yes		WAA_MASK_TYPE	0		
MASK_SENSOR_1	Short integer	Yes		WAA_SENSOR_TYPE	0		
MASK_SENSOR_2	Short integer	Yes		WAA_SENSOR_TYPE	0		
MASK_SENSOR_3	Short integer	Yes		WAA_SENSOR_TYPE	0		
MASK_SENSOR_4	Short integer	Yes		WAA_SENSOR_TYPE	0		
COMMENT_	String	Yes					50
CSM_LEVEL	Short integer	Yes		WAA_CSM_LEVEL	0		
AREA	Double	Yes			0	0	
LEN	Double	Yes			0	0	
SHAPE	Geometry	Yes					
SHAPE_Length	Double	Yes			0	0	
SHAPE_Area	Double	Yes			0	0	

Simple feature class
CSM1_SAR_ANOMALY

Geometry *Point*
Contains M values *No*
Contains Z values *No*

Field name	Data type	Allow nulls	Default value	Domain	Prec-ision	Scale	Length
OBJECTID	Object ID						
EASTING	Double	Yes			0	0	
NORTHING	Double	Yes			0	0	
MAGNITUDE	Double	Yes			0	0	
SHAPE	Geometry	Yes					

Pueblo WAA Geodatabase Schema (cont.)

Page 2

Feature Classes (cont.)

Simple feature class
CSM1_SURVEY_COVERAGE_AREA

Geometry *Polygon*
Contains M values *No*
Contains Z values *No*

Field name	Data type	Allow nulls	Default value	Domain	Prec-ision	Scale	Length
OBJECTID	Object ID						
AREA_NAME	String	Yes					50
AREA_HA	Double	Yes			0	0	
AREA_ACRES	Double	Yes			0	0	
CENTROID_X	Double	Yes			0	0	
CENTROID_Y	Double	Yes			0	0	
COMMENT_	String	Yes					50
SENSOR_TYPE	Short integer	Yes		WAA_SENSOR_TYPE	0		
SURVEY_TYPE	Short integer	Yes		WAA__SURVEY_TYPE	0		
ACREAGE	Double	Yes			0	0	
AREA	Double	Yes			0	0	
LEN	Double	Yes			0	0	
SHAPE	Geometry	Yes					
SHAPE_Length	Double	Yes			0	0	
SHAPE_Area	Double	Yes			0	0	

Simple feature class
CSM1_VEG_AREA

Geometry *Polygon*
Contains M values *No*
Contains Z values *No*

Field name	Data type	Allow nulls	Default value	Domain	Prec-ision	Scale	Length
OBJECTID	Object ID						
POLYID	Long integer	Yes			0		
CH_CLASS	Short integer	Yes			0		
NDVI_MAX	Double	Yes			0	0	
CENTROID_X	Double	Yes			0	0	
CENTROID_Y	Double	Yes			0	0	
AREA_M2	Double	Yes			0	0	
PERIM_M	Double	Yes			0	0	
CIRC_INDEX	Double	Yes			0	0	
TILE_ID	Short integer	Yes			0		
AREA	Double	Yes			0	0	
LEN	Double	Yes			0	0	
SHAPE	Geometry	Yes					
SHAPE_Length	Double	Yes			0	0	
SHAPE_Area	Double	Yes			0	0	

Simple feature class
CSM2_GEOPHYS_MODELED_ANOMALY

Geometry *Point*
Contains M values *No*
Contains Z values *No*

Field name	Data type	Allow nulls	Default value	Domain	Prec-ision	Scale	Length
OBJECTID	Object ID						
EASTING	Double	Yes			0	0	
NORTHING	Double	Yes			0	0	
AMPLITUDE	Double	Yes			0	0	
SENSOR_TYPE	Short integer	Yes		WAA_SENSOR_TYPE	0		
COMMENT_	String	Yes					50
START_DATE	Date	Yes			0	0	8
END_DATE	Date	Yes			0	0	8
SHAPE	Geometry	Yes					

Simple feature class
CSM2_HELI_TARGET_DENS_CONTOUR

Geometry *Polyline*
Contains M values *No*
Contains Z values *No*

Field name	Data type	Allow nulls	Default value	Domain	Prec-ision	Scale	Length
OBJECTID	Object ID						
CONTOUR_VAL	Double	Yes			0	0	
LEN	Double	Yes			0	0	
SHAPE	Geometry	Yes					
SHAPE_Length	Double	Yes			0	0	

Simple feature class
CSM2_NOVA_TRANSECT_ANOMALY

Geometry *Point*
Contains M values *No*
Contains Z values *No*

Field name	Data type	Allow nulls	Default value	Domain	Prec-ision	Scale	Length
OBJECTID	Object ID						
EASTING	Double	Yes			0	0	
NORTHING	Double	Yes			0	0	
SIGNAL	Double	Yes			0	0	
SHAPE	Geometry	Yes					

Simple feature class
CSM2_NOVA_TRANSECT_LINE_SIMP

Geometry *Polyline*
Contains M values *No*
Contains Z values *No*

Field name	Data type	Allow nulls	Default value	Domain	Prec-ision	Scale	Length
OBJECTID	Object ID						
DAY_	String	Yes					10
LEN	Double	Yes			0	0	
SHAPE	Geometry	Yes					
SHAPE_Length	Double	Yes			0	0	

Simple feature class
CSM2_NOVA_TRANSECT_LINE

Geometry *Polyline*
Contains M values *No*
Contains Z values *No*

Field name	Data type	Allow nulls	Default value	Domain	Prec-ision	Scale	Length
OBJECTID	Object ID						
FILE_	Double	Yes			0	0	
DAY_	String	Yes					10
DATE_	Date	Yes			0	0	8
LEN	Double	Yes			0	0	
SHAPE	Geometry	Yes					
SHAPE_Length	Double	Yes			0	0	

Simple feature class
CSM2_SURVEY_COVERAGE_AREA

Geometry *Polygon*
Contains M values *No*
Contains Z values *No*

Field name	Data type	Allow nulls	Default value	Domain	Prec-ision	Scale	Length
OBJECTID	Object ID						
AREA_NAME	String	Yes					50
AREA_HA	Double	Yes			0	0	
AREA_ACRES	Double	Yes			0	0	
CENTROID_X	Double	Yes			0	0	
CENTROID_Y	Double	Yes			0	0	
COMMENT_	String	Yes					50
SENSOR_TYPE	Short integer	Yes		WAA_SENSOR_TYPE	0		
SURVEY_TYPE	Short integer	Yes		WAA__SURVEY_TYPE	0		
ACREAGE	Double	Yes			0	0	
AREA	Double	Yes			0	0	
LEN	Double	Yes			0	0	
SHAPE	Geometry	Yes					
SHAPE_Length	Double	Yes			0	0	
SHAPE_Area	Double	Yes			0	0	

Simple feature class
CSM3_INTRUSIVE_LOCATION

Geometry *Point*
Contains M values *No*
Contains Z values *No*

Field name	Data type	Allow nulls	Default value	Domain	Prec-ision	Scale	Length
OBJECTID	Object ID						
TARGET_NUM	String	Yes					254
LOCATION	String	Yes					254
ANALYSIS_I	String	Yes					254
UTM_Y_M	Double	Yes			0	0	
UTM_X_M	Double	Yes			0	0	
DEPTH_M	Double	Yes			0	0	
SIZE_M	Double	Yes			0	0	
FIT_QUAL	Double	Yes			0	0	
COMMENTS	String	Yes					254
PRE_DEPTH_	Double	Yes			0	0	
ACT_DEPTH_	Double	Yes			0	0	
PRE_SIZE_I	Double	Yes			0	0	
ACT_SIZE_I	Double	Yes			0	0	
FIELD_COMM	String	Yes					254
FIELD_ID	String	Yes					254
FUZ_UNFUZ	String	Yes					254
LIVE_INERT	String	Yes					254
ORD_ORDREL	String	Yes					254
EST_SIZE	Double	Yes			0	0	
PHOTO_1	String	Yes					254
PHOTO_2	String	Yes					254
SITE	String	Yes					254
DATE_	Date	Yes			0	0	8
TIME	Double	Yes			0	0	
SUPERVISOR	String	Yes					254
SHAPE	Geometry	Yes					

Pueblo WAA Geodatabase Schema (cont.)

Domains

Coded value domain
BooleanSymbolValue
Description *Valid values are Yes*
Field type *and No.*
Split policy *Short integer*
Merge policy *Duplicate*

Code	Description
1	Yes
0	No

Coded value domain
WAA_CORRIDOR_TYPE
Description *WIDE AREA*
Field type *ASSESSMENT*
Split policy *CORRIDORS*
Merge policy *Short integer*

Code	Description
0	ROAD
1	POWERLINE
2	RAILROAD
3	FENCE

Coded value domain
WAA_MASK_TYPE
Description *LIST OF TYPES OF*
Field type *WAA MASK AREAS*
Split policy *Short integer*
Merge policy *Default value*

Code	Description
0	ABOVE_GROUND_UTILITY
1	ROAD
2	STRUCTURES
3	VEGETATION
4	BELOW_GROUND_UTLILITY
5	WATER
6	GEOLOGY

Coded value domain
WAA__SURVEY_TYPE
Description *LIST OF SURVEY*
Field type *TYPES*
Split policy *Short integer*
Merge policy *Default value*

Code	Description
0	VEHICULAR_TRANSECTS
1	GROUND_TRANSECTS
2	GROUND_TOTAL_COVERAGE
3	LOW AIRBORNE
4	HIGH AIRBORNE

Coded value domain
WAA_CRATER_TYPE
Description *WAA CRATER*
Field type *TYPES*
Split policy *Short integer*
Merge policy *Default value*

Code	Description
0	DEPRESSION
1	PROBABLE CRATER
2	CRATER

Coded value domain
WAA_SENSOR_TYPE
Description *LIST OF SENSORS*
Field type *USED FOR WAA*
Split policy *Short integer*
Merge policy *Default value*

Code	Description
0	LIDAR
1	VLSO
2	HSI
3	SAR
4	HELI_MTADS
5	GROUND_MAG
6	GROUND_EM

Range domain
WAA_CSM_LEVEL
Description *RANGE OF CMS*
Field type *LEVELS*
Split policy *Short integer*
Merge policy *Default value*

Minimum value	Maximum value
0	5

Coded value domain
WAA_ANALYST
Description *LIST OF ANALYST*
Field type *FOR WIDE AREA*
Split policy *ASSESMENT*
Merge policy *PROJECT*

Code	Description
0	Haiku Sky
1	Kira Tantare
2	Pete Hille
3	Adam Meyer
4	John English
5	Ty Bowdine
6	Lorin Groshong
7	Cam Patterson
8	Terri Ayers

Coded value domain
WAA_FEATURE_TYPE
Description *FOI TYPE LIST FOR*
Field type *WAA*
Split policy *Short integer*
Merge policy *Default value*

Code	Description
0	TARGET_FEATURE
1	IMPACT_FEATURE
2	INFRASTRUCTURE_FEATURE
3	ANOMALY_FEATURES
4	MIXED_FEATURES
5	MANEUVER_AREA

Coded value domain
WAA_AOI_TYPE
Description *AOI TYPE LIST FOR*
Field type *WAA OI*
Split policy *Short integer*
Merge policy *Default value*

Code	Description
0	TARGETING_FEATURE
1	IMPACT_FEATURE
2	RANGE_INFRASTRUCTURE
3	ANOMALY_FEATURES
4	MIXED FEATURES

Kirtland WAA Geodatabase Schema

XML schema file: WAA_Schema_Kirtland.xml

Feature Classes

Simple feature class CSM0_FENCE_GATE

Geometry *Point*
Contains M values *No*
Contains Z values *No*

Field name	Data type	Allow nulls	Default value	Domain	Precision	Scale	Length
OBJECTID	Object ID						
ID	Long integer	Yes			0		
STATUS	String	Yes					25
POC_NAME	String	Yes					30
POC_PHONE	String	Yes					20
SHAPE	Geometry	Yes					

Simple feature class CSM0_FENCE_LINE

Geometry *Polyline*
Contains M values *No*
Contains Z values *No*

Field name	Data type	Allow nulls	Default value	Domain	Precision	Scale	Length
OBJECTID	Object ID						
ID	Long integer	Yes			0		
DESC_	String	Yes					50
LEN	Double	Yes			0	0	
SHAPE	Geometry	Yes					
SHAPE_Length	Double	Yes			0	0	

Simple feature class CSM0_INVESTIGATION_AREA

Geometry *Polygon*
Contains M values *No*
Contains Z values *No*

Field name	Data type	Allow nulls	Default value	Domain	Precision	Scale	Length
OBJECTID	Object ID						
NARRATIVE	String	Yes					240
SITE_NAME	String	Yes					50
AREA	Double	Yes			0	0	
AREA_SQFT	Double	Yes			0	0	
ACREAGE	Double	Yes			0	0	
AREA_1	Double	Yes			0	0	
LEN	Double	Yes			0	0	
SHAPE	Geometry	Yes					
SHAPE_Length	Double	Yes			0	0	
SHAPE_Area	Double	Yes			0	0	

Simple feature class CSM0_OIL_TANK_AREA

Geometry *Polygon*
Contains M values *No*
Contains Z values *No*

Field name	Data type	Allow nulls	Default value	Domain	Precision	Scale	Length
OBJECTID	Object ID						
ID	Long integer	Yes			0		
AREA	Double	Yes			0	0	
LEN	Double	Yes			0	0	
SHAPE	Geometry	Yes					
SHAPE_Length	Double	Yes			0	0	
SHAPE_Area	Double	Yes			0	0	

Simple feature class CSM0_SITE_BOUNDARY

Geometry *Polygon*
Contains M values *No*
Contains Z values *No*

Field name	Data type	Allow nulls	Default value	Domain	Precision	Scale	Length
OBJECTID	Object ID						
ID	Long integer	Yes			0		
AREA	Double	Yes			0	0	
ACREAGE	Double	Yes			0	0	
TEXT	String	Yes					25
AREA_1	Double	Yes			0	0	
LEN	Double	Yes			0	0	
SHAPE	Geometry	Yes					
SHAPE_Length	Double	Yes			0	0	
SHAPE_Area	Double	Yes			0	0	

Simple feature class CSM0_TARGET_AREA

Geometry *Polygon*
Contains M values *No*
Contains Z values *No*

Field name	Data type	Allow nulls	Default value	Domain	Precision	Scale	Length
OBJECTID	Object ID						
NARRATIVE	String	Yes					240
SITE_NAME	String	Yes					50
AREA	Double	Yes			0	0	
ACREAGE	Double	Yes			0	0	
AREA_1	Double	Yes			0	0	
LEN	Double	Yes			0	0	
SHAPE	Geometry	Yes					
SHAPE_Length	Double	Yes			0	0	
SHAPE_Area	Double	Yes			0	0	

Simple feature class CSM0_TARGET

Geometry *Point*
Contains M values *No*
Contains Z values *No*

Field name	Data type	Allow nulls	Default value	Domain	Precision	Scale	Length
OBJECTID	Object ID						
ID	Long integer	Yes			0		
SITE_NAME	String	Yes					15
X	Double	Yes			0	0	
Y	Double	Yes			0	0	
SHAPE	Geometry	Yes					

Simple feature class CSM0_UTILITY_LINE

Geometry *Polyline*
Contains M values *No*
Contains Z values *No*

Field name	Data type	Allow nulls	Default value	Domain	Precision	Scale	Length
OBJECTID	Object ID						
ID	Long integer	Yes			0		
LEN	Double	Yes			0	0	
SHAPE	Geometry	Yes					
SHAPE_Length	Double	Yes			0	0	

Simple feature class CSM1_AREA_OF_INTEREST

Geometry *Polygon*
Contains M values *No*
Contains Z values *No*

Field name	Data type	Allow nulls	Default value	Domain	Precision	Scale	Length
OBJECTID	Object ID						
AOI_TYPE	Short integer	Yes		WAA_AOI_TYPE	0		
AREA_HA	Double	Yes			0	0	
AREA_ACRES	Double	Yes			0	0	
CENTROID_X	Double	Yes			0	0	
CENTROID_Y	Double	Yes			0	0	
COMMENT_	String	Yes					50
AREA	Double	Yes			0	0	
LEN	Double	Yes			0	0	
SHAPE	Geometry	Yes					
SHAPE_Length	Double	Yes			0	0	
SHAPE_Area	Double	Yes			0	0	

Simple feature class CSM1_CRATERING_FEATURE

Geometry *Polygon*
Contains M values *No*
Contains Z values *No*

Field name	Data type	Allow nulls	Default value	Domain	Precision	Scale	Length
OBJECTID	Object ID						
CRATER_TYPE	Short integer	Yes	0	WAA_CRATER_TYPE	0		
MIN_Z	Double	Yes			0	0	
MAX_Z	Double	Yes			0	0	
COMMENT_	String	Yes					50
CENTROID_Y	Double	Yes			0	0	
CENTROID_X	Double	Yes			0	0	
CRATER_DEPTH_M	Double	Yes			0	0	
AREA	Double	Yes			0	0	
LEN	Double	Yes			0	0	
SHAPE	Geometry	Yes					
SHAPE_Length	Double	Yes			0	0	
SHAPE_Area	Double	Yes			0	0	

Simple feature class CSM1_FEATURE_OF_INTEREST

Geometry *Polygon*
Contains M values *No*
Contains Z values *No*

Field name	Data type	Allow nulls	Default value	Domain	Precision	Scale	Length
OBJECTID	Object ID						
FEATURE_TYPE	Short integer	Yes		WAA_FEATURE_TYPE	0		
VALIDATION	Short integer	Yes	0	BooleanSymbolValue	0		
CENTROID_X	Double	Yes			0	0	
CENTROID_Y	Double	Yes			0	0	
AREA_HA	Double	Yes			0	0	
AREA_ACRES	Double	Yes			0	0	
COMMENT_	String	Yes					50
PRIMARY_SENSOR	Short integer	Yes		WAA_SENSOR_TYPE	0		
SECONDARY_SENSOR	Short integer	Yes		WAA_SENSOR_TYPE	0		
COMPANY	Short integer	Yes		WAA_DATA_PROVIDER	0		
AREA	Double	Yes			0	0	
LEN	Double	Yes			0	0	
SHAPE	Geometry	Yes					
SHAPE_Length	Double	Yes			0	0	
SHAPE_Area	Double	Yes			0	0	

Kirtland WAA Geodatabase Schema (cont.)

Feature Classes (cont.)

Simple feature class CSM1_MASK_AREA
Geometry *Polygon*
Contains M values *No*
Contains Z values *No*

Field name	Data type	Allow nulls	Default value	Domain	Precision	Scale	Length
OBJECTID	Object ID						
MASK_TYPE	Short integer	Yes		WAA_MASK_TYPE	0		
MASK_SENSOR_1	Short integer	Yes		WAA_SENSOR_TYPE	0		
MASK_SENSOR_2	Short integer	Yes		WAA_SENSOR_TYPE	0		
MASK_SENSOR_3	Short integer	Yes		WAA_SENSOR_TYPE	0		
MASK_SENSOR_4	Short integer	Yes		WAA_SENSOR_TYPE	0		
COMMENT_	String	Yes					50
CSM_LEVEL	Short integer	Yes		WAA_CSM_LEVEL	0		
AREA	Double	Yes			0	0	
LEN	Double	Yes			0	0	
SHAPE	Geometry	Yes					
SHAPE_Length	Double	Yes			0	0	
SHAPE_Area	Double	Yes			0	0	

Simple feature class CSM1_SURVEY_COVERAGE_AREA
Geometry *Polygon*
Contains M values *No*
Contains Z values *No*

Field name	Data type	Allow nulls	Default value	Domain	Precision	Scale	Length
OBJECTID	Object ID						
AREA_NAME	String	Yes					50
AREA_HA	Double	Yes			0	0	
AREA_ACRES	Double	Yes			0	0	
CENTROID_X	Double	Yes			0	0	
CENTROID_Y	Double	Yes			0	0	
COMMENT_	String	Yes					50
SENSOR_TYPE	Short integer	Yes		WAA_SENSOR_TYPE	0		
SURVEY_TYPE	Short integer	Yes		WAA__SURVEY_TYPE	0		
AREA	Double	Yes			0	0	
LEN	Double	Yes			0	0	
SHAPE	Geometry	Yes					
SHAPE_Length	Double	Yes			0	0	
SHAPE_Area	Double	Yes			0	0	

Simple feature class CSM2_CALIBRATION_LINE
Geometry *Polyline*
Contains M values *No*
Contains Z values *No*

Field name	Data type	Allow nulls	Default value	Domain	Precision	Scale	Length
OBJECTID	Object ID						
ID	Long integer	Yes			0		
LEN	Double	Yes			0	0	
SHAPE	Geometry	Yes					
SHAPE_Length	Double	Yes			0	0	

Simple feature class CSM2_COG_LINE
Geometry *Polyline*
Contains M values *No*
Contains Z values *No*

Field name	Data type	Allow nulls	Default value	Domain	Precision	Scale	Length
OBJECTID	Object ID						
LINE	String	Yes					254
LEN	Double	Yes			0	0	
SHAPE	Geometry	Yes					
SHAPE_Length	Double	Yes			0	0	

Simple feature class CSM2_GEOPHYS_MODELED_ANOMALY
Geometry *Point*
Contains M values *No*
Contains Z values *No*

Field name	Data type	Allow nulls	Default value	Domain	Precision	Scale	Length
OBJECTID	Object ID						
EASTING	Double	Yes			0	0	
NORTHING	Double	Yes			0	0	
AMPLITUDE	Double	Yes			0	0	
SENSOR_TYPE	Short integer	Yes		WAA_SENSOR_TYPE	0		
COMMENT_	String	Yes					50
START_DATE	Date	Yes			0	0	8
END_DATE	Date	Yes			0	0	8
SHAPE	Geometry	Yes					

Simple feature class CSM2_GEOPHYS_TRANSECT_ANOMALY
Geometry *Point*
Contains M values *No*
Contains Z values *No*

Field name	Data type	Allow nulls	Default value	Domain	Precision	Scale	Length
OBJECTID	Object ID						
TARG_NUM	String	Yes					254
EASTING_M	Double	Yes			0	0	
NORTHING_M	Double	Yes			0	0	
DEPTH_M	Double	Yes			0	0	
SENSOR_TYP	Double	Yes			0	0	
LIKELIHOOD	Double	Yes			0	0	
SIZE_CLASS	String	Yes					254
MOMENT	Double	Yes			0	0	
ALPHA	Double	Yes			0	0	
BETA	Double	Yes			0	0	
MAG_VALUE	Double	Yes			0	0	
EM_VALUE	Double	Yes			0	0	
FULLW_MAG	Double	Yes			0	0	
FULLW_EM	Double	Yes			0	0	
COMMENTS	String	Yes					254
SHAPE	Geometry	Yes					

Simple feature class CSM2_SURVEY_COVERAGE_AREA
Geometry *Polygon*
Contains M values *No*
Contains Z values *No*

Field name	Data type	Allow nulls	Default value	Domain	Precision	Scale	Length
OBJECTID	Object ID						
ID	Long integer	Yes			0		
AREA_NAME	String	Yes					20
AREA_HA	Float	Yes			0	0	
AREA_ACRES	Float	Yes			0	0	
AREA	Double	Yes			0	0	
LEN	Double	Yes			0	0	
SHAPE	Geometry	Yes					
SHAPE_Length	Double	Yes			0	0	
SHAPE_Area	Double	Yes			0	0	

Domains

Coded value domain BooleanSymbolValue
Description *Valid values are Yes*
Field type *and No.*
Split policy *Short integer*
Merge policy *Duplicate*

Code	Description
1	Yes
0	No

Coded value domain WAA__SURVEY_TYPE
Description *LIST OF SURVEY*
Field type *TYPES*
Split policy *Short integer*
Merge policy *Default value*

Code	Description
0	VEHICULAR_TRANSECTS
1	GROUND_TRANSECTS
2	GROUND_TOTAL_COVERAGE
3	LOW AIRBORNE
4	HIGH AIRBORNE

Coded value domain WAA_AOI_TYPE
Description *AOI TYPE LIST FOR*
Field type *WAA OI*
Split policy *Short integer*
Merge policy *Default value*

Code	Description
0	TARGETING_FEATURE
1	IMPACT_FEATURE
2	RANGE_INFRASTRUCTURE
3	ANOMALY_FEATURES
4	MIXED FEATURES

Coded value domain WAA_CORRIDOR_TYPE
Description *WIDE AREA*
Field type *ASSESSMENT*
Split policy *CORRIDORS*
Merge policy *Short integer*

Code	Description
0	ROAD
1	POWERLINE
2	RAILROAD
3	FENCE

Kirtland WAA Geodatabase Schema (cont.)

Domains (cont.)

Coded value domain
WAA_CRATER_TYPE

Description *WAA CRATER*
Field type *TYPES*
Split policy *Short integer*
Merge policy *Default value*

Code	Description
0	DEPRESSION
1	PROBABLE CRATER
2	CRATER

Coded value domain
WAA_MASK_TYPE

Description *LIST OF TYPES OF*
Field type *WAA MASK AREAS*
Split policy *Short integer*
Merge policy *Default value*

Code	Description
0	ABOVE_GROUND_UTILITY
1	ROAD
2	STRUCTURES
3	VEGETATION
4	BELOW_GROUND_UTLILITY
5	WATER
6	GEOLOGY

Range domain
WAA_CSM_LEVEL

Description *RANGE OF CMS*
Field type *LEVELS*
Split policy *Short integer*
Merge policy *Default value*

Minimum value	Maximum value
0	5

Coded value domain
WAA_SENSOR_TYPE

Description *LIST OF SENSORS*
Field type *USED FOR WAA*
Split policy *Short integer*
Merge policy *Default value*

Code	Description
0	LIDAR
1	VLSO
2	HSI
3	SAR
4	HELI_MTADS
5	GROUND_MAG
6	GROUND_EM

Coded value domain
WAA_DATA_PROVIDER

Description *Data contractor list*
Field type *Short integer*
Split policy *Default value*
Merge policy *Default value*

Code	Description
0	Sky Research
1	URS
2	NOVA
3	HGL
4	SANDIA

Coded value domain
WAA_FEATURE_TYPE

Description *FOI TYPE LIST FOR*
Field type *WAA*
Split policy *Short integer*
Merge policy *Default value*

Code	Description
0	TARGET_FEATURE
1	IMPACT_FEATURE
2	INFRASTRUCTURE_FEATURE
3	ANOMALY_FEATURES
4	MIXED_FEATURES
5	MANEUVER_AREA

Victorville WAA Geodatabase Schema

Page 1

XML schema file: WAA_Schema_Victorville.xml

Feature Classes

Simple feature class **CSM0_ASR_RANGE_AREA**
Geometry *Polygon* · Contains M values *No* · Contains Z values *No*

Field name	Data type	Allow nulls	Default value	Domain	Precision	Scale	Length
OBJECTID	Object ID						
ID	Long integer	Yes			0		
BUFFERDIST	Double	Yes			0	0	
AREA	Double	Yes			0	0	
LEN	Double	Yes			0	0	
SHAPE	Geometry	Yes					
SHAPE_Length	Double	Yes			0	0	
SHAPE_Area	Double	Yes			0	0	

Simple feature class **CSM0_MEANS_LAKE**
Geometry *Polygon* · Contains M values *No* · Contains Z values *No*

Field name	Data type	Allow nulls	Default value	Domain	Precision	Scale	Length
OBJECTID	Object ID						
NAME	String	Yes					65
FTYPE	String	Yes					24
SQKM	Double	Yes			0	0	
SQMI	Double	Yes			0	0	
AREA	Double	Yes			0	0	
LEN	Double	Yes			0	0	
SHAPE	Geometry	Yes					
SHAPE_Length	Double	Yes			0	0	
SHAPE_Area	Double	Yes			0	0	

Simple feature class **CSM0_ROAD**
Geometry *Polyline* · Contains M values *No* · Contains Z values *No*

Field name	Data type	Allow nulls	Default value	Domain	Precision	Scale	Length
OBJECTID	Object ID						
LAYER	String	Yes					254
LINETYPE	String	Yes					254
TEXT	String	Yes					254
LEN	Double	Yes			0	0	
SHAPE	Geometry	Yes					
SHAPE_Length	Double	Yes			0	0	

Simple feature class **CSM0_SITE_BOUNDARY**
Geometry *Polygon* · Contains M values *No* · Contains Z values *No*

Field name	Data type	Allow nulls	Default value	Domain	Precision	Scale	Length
OBJECTID	Object ID						
AREA_SQM	Double	Yes			0	0	
ACREAGE	Double	Yes			0	0	
ASR_AREA	String	Yes					5
ASR_USAGE	String	Yes					30
AREA	Double	Yes			0	0	
LEN	Double	Yes			0	0	
SHAPE	Geometry	Yes					
SHAPE_Length	Double	Yes			0	0	
SHAPE_Area	Double	Yes			0	0	

Simple feature class **CSM0_TARGET_CIRCLE_PBR15**
Geometry *Polygon* · Contains M values *No* · Contains Z values *No*

Field name	Data type	Allow nulls	Default value	Domain	Precision	Scale	Length
OBJECTID	Object ID						
ID	Long integer	Yes			0		
AREA	Double	Yes			0	0	
LEN	Double	Yes			0	0	
SHAPE	Geometry	Yes					
SHAPE_Length	Double	Yes			0	0	
SHAPE_Area	Double	Yes			0	0	

Simple feature class **CSM1_CRATERING_FEATURE**
Geometry *Polygon* · Contains M values *No* · Contains Z values *No*

Field name	Data type	Allow nulls	Default value	Domain	Precision	Scale	Length
OBJECTID	Object ID						
CRATER_TYPE	Short integer	Yes	0	WAA_CRATER_TYPE	0		
MIN_Z	Double	Yes			0	0	
MAX_Z	Double	Yes			0	0	
COMMENT_	String	Yes					50
CENTROID_Y	Double	Yes			0	0	
CENTROID_X	Double	Yes			0	0	
CRATER_DEPTH_M	Double	Yes			0	0	
AREA	Double	Yes			0	0	
LEN	Double	Yes			0	0	
SHAPE	Geometry	Yes					
SHAPE_Length	Double	Yes			0	0	
SHAPE_Area	Double	Yes			0	0	

Simple feature class **CSM1_FEATURE_OF_INTEREST**
Geometry *Polygon* · Contains M values *No* · Contains Z values *No*

Field name	Data type	Allow nulls	Default value	Domain	Precision	Scale	Length
OBJECTID	Object ID						
FEATURE_TYPE	Short integer	Yes		WAA_FEATURE_TYPE	0		
VALIDATION	Short integer	Yes	0	BooleanSymbolValue	0		
CENTROID_X	Double	Yes			0	0	
CENTROID_Y	Double	Yes			0	0	
AREA_HA	Double	Yes			0	0	
AREA_ACRES	Double	Yes			0	0	
COMMENT_	String	Yes					50
PRIMARY_SENSOR	Short integer	Yes		WAA_SENSOR_TYPE	0		
SECONDARY_SENSOR	Short integer	Yes		WAA_SENSOR_TYPE	0		
AREA	Double	Yes			0	0	
LEN	Double	Yes			0	0	
SHAPE	Geometry	Yes					
SHAPE_Length	Double	Yes			0	0	
SHAPE_Area	Double	Yes			0	0	

Simple feature class **CSM1_SURVEY_COVERAGE_AREA**
Geometry *Polygon* · Contains M values *No* · Contains Z values *No*

Field name	Data type	Allow nulls	Default value	Domain	Precision	Scale	Length
OBJECTID	Object ID						
AREA_NAME	String	Yes					50
AREA_HA	Double	Yes			0	0	
AREA_ACRES	Double	Yes			0	0	
CENTROID_X	Double	Yes			0	0	
CENTROID_Y	Double	Yes			0	0	
COMMENT_	String	Yes					50
SENSOR_TYPE	Short integer	Yes		WAA_SENSOR_TYPE	0		
SURVEY_TYPE	Short integer	Yes		WAA__SURVEY_TYPE	0		
ACREAGE	Double	Yes			0	0	
AREA	Double	Yes			0	0	
LEN	Double	Yes			0	0	
SHAPE	Geometry	Yes					
SHAPE_Length	Double	Yes			0	0	
SHAPE_Area	Double	Yes			0	0	

Simple feature class **CSM2_COG_TRANSECT_LINE**
Geometry *Polyline* · Contains M values *No* · Contains Z values *No*

Field name	Data type	Allow nulls	Default value	Domain	Precision	Scale	Length
OBJECTID	Object ID						
FILE_	Double	Yes			0	0	
DAY	Short integer	Yes			0		
LEN	Double	Yes			0	0	
SHAPE	Geometry	Yes					
SHAPE_Length	Double	Yes			0	0	

Simple feature class **CSM2_GEOPHYS_MODELED_ANOMALY**
Geometry *Point* · Contains M values *No* · Contains Z values *No*

Field name	Data type	Allow nulls	Default value	Domain	Precision	Scale	Length
OBJECTID	Object ID						
EASTING	Double	Yes			0	0	
NORTHING	Double	Yes			0	0	
AMPLITUDE	Double	Yes			0	0	
SENSOR_TYPE	Short integer	Yes		WAA_SENSOR_TYPE	0		
COMMENT_	String	Yes					50
START_DATE	Date	Yes			0	0	8
END_DATE	Date	Yes			0	0	8
SENSOR_ALTITUDE	Short integer	Yes			0		
SURVEY_TYPE	Short integer	Yes		WAA__SURVEY_TYPE	0		
SHAPE	Geometry	Yes					

Victorville WAA Geodatabase Schema (cont.)

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Domains

Coded value domain
BooleanSymbolValue
Description *Valid values are Yes*
Field type *and No.*
Split policy *Short integer*
Merge policy *Duplicate*

Code	Description
1	Yes
0	No

Coded value domain
WAA_SENSOR_TYPE
Description *LIST OF SENSORS*
Field type *USED FOR WAA*
Split policy *Short integer*
Merge policy *Default value*

Code	Description
0	LIDAR
1	VLSO
2	HSI
3	SAR
4	HELI_MTADS
5	GROUND_MAG
6	GROUND_EM

Coded value domain
WAA__SURVEY_TYPE
Description *LIST OF SURVEY*
Field type *TYPES*
Split policy *Short integer*
Merge policy *Default value*

Code	Description
0	VEHICULAR_TRANSECTS
1	GROUND_TRANSECTS
2	GROUND_TOTAL_COVERAGE
3	LOW AIRBORNE
4	HIGH AIRBORNE

Coded value domain
WAA_CRATER_TYPE
Description *WAA CRATER*
Field type *TYPES*
Split policy *Short integer*
Merge policy *Default value*

Code	Description
0	DEPRESSION
1	PROBABLE CRATER
2	CRATER

Coded value domain
WAA_FEATURE_TYPE
Description *FOI TYPE LIST FOR*
Field type *WAA*
Split policy *Short integer*
Merge policy *Default value*

Code	Description
0	TARGET_FEATURE
1	IMPACT_FEATURE
2	INFRASTRUCTURE_FEATURE
3	ANOMALY_FEATURES
4	MIXED_FEATURES
5	MANEUVER_AREA

Camp Beale WAA Geodatabase Schema

XML schema file: WAA_Schema_CampBeale.xml

Feature Classes

Simple feature class
CSM0_SITE_BOUNDARY

Geometry *Polygon*
Contains M values *No*
Contains Z values *No*

Field name	Data type	Allow nulls	Default value	Domain	Prec-ision	Scale	Length
OBJECTID	Object ID						
AREA	Double	Yes			0	0	
PERIMETER	Double	Yes			0	0	
BOUNDARY	String	Yes					16
ACRES	Double	Yes			0	0	
S_NUMB	String	Yes					15
S_NAME	String	Yes					100
AREA_1	Double	Yes			0	0	
LEN	Double	Yes			0	0	
SHAPE	Geometry	Yes					
SHAPE_Length	Double	Yes			0	0	
SHAPE_Area	Double	Yes			0	0	

Simple feature class
CSM1_SURVEY_COVERAGE_AREA

Geometry *Polygon*
Contains M values *No*
Contains Z values *No*

Field name	Data type	Allow nulls	Default value	Domain	Prec-ision	Scale	Length
OBJECTID	Object ID						
ID	Long integer	Yes			0		
AREA	Double	Yes			0	0	
LEN	Double	Yes			0	0	
SHAPE	Geometry	Yes					
SHAPE_Length	Double	Yes			0	0	
SHAPE_Area	Double	Yes			0	0	

Simple feature class
CSM2_GEOPHYS_MODELED_ANOMALY

Geometry *Point*
Contains M values *No*
Contains Z values *No*

Field name	Data type	Allow nulls	Default value	Domain	Prec-ision	Scale	Length
OBJECTID	Object ID						
ID	Double	Yes			0	0	
X	Double	Yes			0	0	
Y	Double	Yes			0	0	
SHAPE	Geometry	Yes					

Borrego WAA Geodatabase Schema

XML schema file: WAA_Schema_Borrego.xml

Feature Classes

Simple feature class
CSM0_SITE_BOUNDARY

Geometry *Polygon*
Contains M values *No*
Contains Z values *No*

Field name	Data type	Allow nulls	Default value	Domain	Prec-ision	Scale	Length
OBJECTID	Object ID						
NARRATIVE	String	Yes					50
AREA	Double	Yes			0	0	
ACREAGE	Double	Yes			0	0	
SITE_AREA	String	Yes					20
AREA_1	Double	Yes			0	0	
LEN	Double	Yes			0	0	
SHAPE	Geometry	Yes					
SHAPE_Length	Double	Yes			0	0	
SHAPE_Area	Double	Yes			0	0	

Simple feature class
CSM0_TARGET

Geometry *Point*
Contains M values *Yes*
Contains Z values *Yes*

Field name	Data type	Allow nulls	Default value	Domain	Prec-ision	Scale	Length
OBJECTID	Object ID						
ID	Long integer	Yes			0		
X	Double	Yes			0	0	
Y	Double	Yes			0	0	
LOC_ID	String	Yes					5
DESC_	String	Yes					75
SHAPE	Geometry	Yes					

Simple feature class
CSM1_AREA_OF_INTEREST

Geometry *Polygon*
Contains M values *No*
Contains Z values *No*

Field name	Data type	Allow nulls	Default value	Domain	Prec-ision	Scale	Length
OBJECTID	Object ID						
ID	Long integer	Yes			0		
COMMENTS	String	Yes					50
FEATURE_TYPE	Short integer	Yes		Feature_Type	0		
DESCRIPTION	String	Yes					50
PRIMARY_SENSOR	Short integer	Yes		Sensor	0		
ACRES	Double	Yes			0	0	
CENTROID_X	Double	Yes			0	0	
CENTROID_Y	Double	Yes			0	0	
AREA	Double	Yes			0	0	
LEN	Double	Yes			0	0	
SHAPE	Geometry	Yes					
SHAPE_Length	Double	Yes			0	0	
SHAPE_Area	Double	Yes			0	0	

Simple feature class
CSM1_FEATURE_OF_INTEREST

Geometry *Polygon*
Contains M values *No*
Contains Z values *No*

Field name	Data type	Allow nulls	Default value	Domain	Prec-ision	Scale	Length
OBJECTID	Object ID						
ID	Long integer	Yes			0		
COMMENTS	String	Yes					50
FEATURE_TYPE	Short integer	Yes		Feature_Type	0		
DESCRIPTION	String	Yes					50
PRIMARY_SENSOR	Short integer	Yes		Sensor	0		
ACRES	Double	Yes			0	0	
CENTROID_X	Double	Yes			0	0	
CENTROID_Y	Double	Yes			0	0	
AREA	Double	Yes			0	0	
LEN	Double	Yes			0	0	
SHAPE	Geometry	Yes					
SHAPE_Length	Double	Yes			0	0	
SHAPE_Area	Double	Yes			0	0	

Simple feature class
CSM1_INFRASTRUCTURE_CORRIDOR

Geometry *Polyline*
Contains M values *No*
Contains Z values *No*

Field name	Data type	Allow nulls	Default value	Domain	Prec-ision	Scale	Length
OBJECTID	Object ID						
ID	Long integer	Yes			0		
LEN	Double	Yes			0	0	
SHAPE	Geometry	Yes					
SHAPE_Length	Double	Yes			0	0	

Simple feature class
CSM1_SURVEY_COVERAGE_AREA

Geometry *Polygon*
Contains M values *No*
Contains Z values *No*

Field name	Data type	Allow nulls	Default value	Domain	Prec-ision	Scale	Length
OBJECTID	Object ID						
ID	Long integer	Yes			0		
AREA_METER	Double	Yes			0	0	
AREA_ACRES	Double	Yes			0	0	
AREA	Double	Yes			0	0	
LEN	Double	Yes			0	0	
SHAPE	Geometry	Yes					
SHAPE_Length	Double	Yes			0	0	
SHAPE_Area	Double	Yes			0	0	

Domains

Coded value domain
Feature_Type

Description *Feature Type for*
Field type *WAA AOI FC*
Split policy *Short integer*
Merge policy *Default value*

Code	Description
0	Ground Feature
1	Target Feature
2	Infrastructure

Coded value domain
Sensor

Description *WAA Sensor*
Field type *Technology*
Split policy *Short integer*
Merge policy *Default value*

Code	Description
0	LiDAR
1	VLSO
2	HSI
3	SAR
4	HELI MTADS
5	Ground MTADS